SCIENTIFIC AMERICAN SUPPLEMENT. No 1045

Scientific American Supplement, Vol. XLI. No. 1045.
Scientific American, established 1845.

NEW YORK, JANUARY 11, 1896.

Scientific American Supplement, $5 a year.
Scientific American and Supplement, $7 a year.

MANUFACTURE OF PHOTOGRAPHIC PAPER.

HAVING described the method of manufacture of photographic plates, we shall now give an account of that of photographic paper, taking as our guide the installation of the Messrs. Lumiere, at Lyons, for the manufacture of citrate of silver and gelatino-bromide papers. The engravings that accompany this article were made from photographs taken at the establishment.

PREPARATION OF THE EMULSION.

The gelatino-bromide emulsion for paper is prepared like that used for plates, with the sole difference that it is not left to "ripen." For example, it is obtained by mixing the two following solutions: (1) 4 lb. 5 oz. of gelatine, 8 lb. 12 oz. of bromide of potassium and 450 grains of iodide of potassium in 5 quarts of water; (2) 1 lb. 6 oz. of nitrate of silver in 2·5 quarts of water. These two solutions are prepared in a light laboratory. The emulsion is made in a laboratory lighted with a green light.

The citrate of silver emulsion is obtained by the same process in replacing the bromide of potassium by citrate of soda or potassa.

FIG. 1.—MACHINE FOR SPREADING EMULSION UPON PHOTOGRAPHIC PAPER.

SPREADING THE EMULSION UPON PAPER.

The spreading of the emulsion upon paper is effected through improved machines that we represent in Fig. 1.

The paper employed is a special one of close tex-

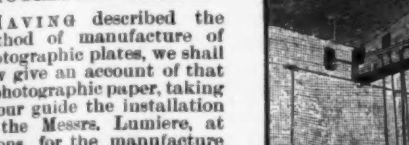


FIG. 2.—DIAGRAM OF THE MACHINE.

ture and made of very pure pulp. It should be free from metallic particles, which give spots with the salts of silver. It reaches the establishment in rolls of from 60 to 80 yards in length and from 24 to 30 inches in width. The emulsion is distributed over the paper by a process analogous to that employed for plates. The distributing system is seen in front of the machine. As soon as it is covered with emulsion, the paper passes over a cooling cylinder upon which the emulsion coagulates. It next enters a long curved wooden box 30 inches in width, 8 in height, and from 15 to 18 yards in length, in which a current of dry and pure air circulates. The finished paper winds around a bobbin at the extremity of the drier.

All the parts of the machine are actuated electrically, and each operative has in front of her an electric distributing board that permits her at every instant to stop or start such or such a part, according to exigencies. The machines used for spreading the emulsion at the Messrs. Lumiere's were invented by these gentlemen after long and patient tentatives. They are marvels of ingenuity, in which are united the latest discoveries in physics and mechanics. The air employed for the drying of the citrate of silver paper is heated to 40° and is dry. Heat must not be employed for drying the gelatino-bromide paper. It is necessary to proceed at the ordinary temperature by way of hanging, as for fabrics. In Fig. 2 we show the arrangement adopted. In measure as the emulsion is spread upon the paper by the same machine as for the citrate paper, a special arrangement puts the paper in festoons in order to effect the drying of it. An inclined chain, B, is provided with rods and revolves at such a velocity that while one of its rods is traversing the entire length of the chain, the machine pays out a whole length of paper. The wooden bars that serve to suspend the paper are placed in the box, M, which is open above. As soon as one of the rods of the chain carries along one of these bars, the paper, too, is carried along, as shown in the figure. The bar, with the paper, passes over a nearly horizontal chain with a slow motion, and moves forward at the rate of about 6 inches during the time necessary for the ascent of a bar upon the inclined chain. The paper hangs in folds (Fig. 4). Upon the horizontal chain the bars travel over a curve of from 20 to 25 yards. At the extremity there is a device that removes the bars and winds up the paper. All this is done mechanically and under protection from the dust by a very few operatives. The rooms in which the emulsion is spread upon the paper are lighted by green light, especially for the gelatino-bromide paper.

At the Lumiere establishment 18,000 feet of paper a day (say 32,250 square feet) can be prepared with seven machines.

CUTTING AND SORTING OF THE PHOTOGRAPHIC PAPER.

The photographic papers are sold in rolls or cut into sizes corresponding to the plates. The cutting is done by means of machines that do not differ from those used by paper manufacturers. The sorting of the paper is done in a large room, illuminated by incandescent electric light, rendered inactinic (Fig. 3). The work is performed by women, who wear white gloves, so as not to soil the paper, and to be able to examine it very carefully. These operatives classify and put aside all the paper that is defective. Every defect is marked with a cross by means of a pencil. The perfect paper is put up in packages. That which shows inequalities, excoriations or defects in the pulp is examined again in order to see whether, if deprived of defective parts, it cannot be converted into sheets of smaller sizes. Fig. 4 shows the room in which the sorting and re-examination of the paper is done at the Messrs. Lumiere's.

Finally, all the preparations of paper are tested under reinforced or feeble negatives. The proofs obtained are compared with those obtained with typical paper. If the proof is

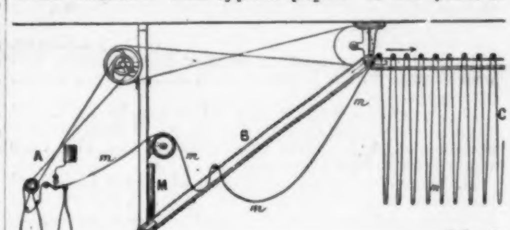


FIG. 4.

At A is seen the machine represented in Fig. 2. At B is seen the arrangement for putting the paper in folds (c). The sheet of paper is followed by the letters, M, M, M.

good, the paper is delivered to the trade; if not, it is rejected.

The sorting of the gelatino-bromide paper is done in profound darkness and by green light.

Such, in their broad lines, are the processes employed in the industry for the manufacture of the sensitized papers used by professional and amateur photographers.—La Nature.

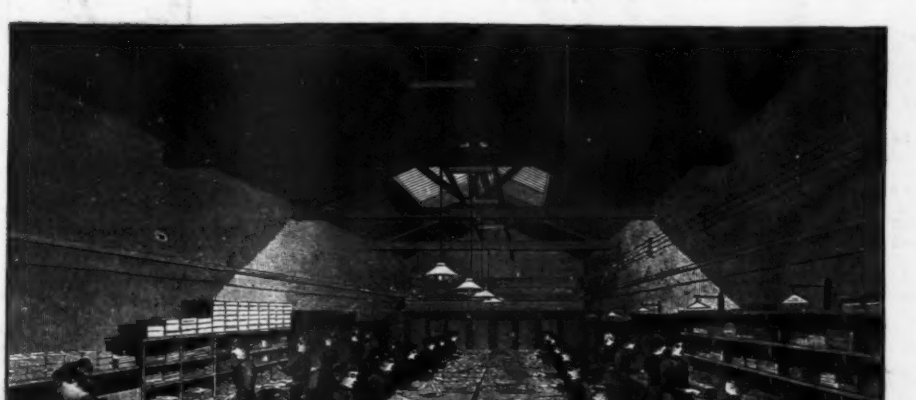


FIG. 3.—SORTING OF THE PAPER.

THE SPECIAL RULES FOR DANGEROUS OCCUPATIONS.

WHITE LEAD WORKS.

IN a recent issue we referred to the appointment of two parliamentary committees to inquire into the conditions under which employes labor in industries that are thought to be dangerous to health. We have already expressed our opinion as to the use of further inquiries, so that comment upon this point is needless. For some time, however, we have been collecting information about the practicability of the rules that are now in force, and the present moment appears to afford a most fitting opportunity for utilizing the same. We therefore propose to publish a copy of the special rules for the principal industries related to chemistry, and to add thereto the criticisms that have been received or that we feel

justified in making after having considered the general bearings of what we have gathered. In this way we shall record for reference the conditions of the moment, and also, we trust, afford some guidance to those who are anxious to further investigate dangerous trades with a view to adding to or modifying the present regulations.

This week we deal with white lead works. There is danger in this industry when the regulations are not followed out by the employes, but as a rule they act up to their instructions. It is absolutely necessary that the 9th section of the act of 1891 be made as public as possible. It renders the employe as well as the employer liable to a fine if any of the rules are willfully not complied with. There is room, however, for great improvement in the methods of enforcing this section, as it has proved troublesome in certain cases to make practical use of the power thus given to the employer. Fortunately the threat is so far generally enough. We would here impress upon those intending to further improve our existing legislation that, while acting wisely in perfecting all preventive measures, it will be unwise to prohibit the employment of women in all departments of white lead works where they would come in contact with white lead.

We consider this would be a great hardship to the women, who at present earn a good livelihood by working in lead factories, and it would also tend to drive this trade to the Continent, where cheap labor can be obtained without any irksome regulations.

The following are the special rules now in force for the management of white lead works. In the main the rules also apply to the correlated processes of lead smelting and working, and the preparation of red lead, litharge, etc.:

DUTIES OF OCCUPIERS.

1. They shall provide respirators, overall suits and head coverings to be worn by the persons employed in the departments enumerated below, under "Duties of Persons Employed."

2. They shall take care that every stack is fitted with a standpipe, or movable hose, and an adequate supply of water, distributed by a very fine rose or watering can, for damping the white bed before stripping.

3. They shall see that no female shall be employed without a certificate of fitness from a medical man, to be obtained within one week from the date of employment.

4. They shall see that no person shall be re-employed after absence through illness without a certificate from a medical man.

5. They shall provide overalls for females in all blue beds where the returns are used without being remelted, and overalls and head coverings for females in all other parts of the works except the casting shops.

6. That the wearing of shoes and stockings be optional, but that no females shall be permitted to wear the same shoes and stockings in the works as they wear in going to and from the place of employment.

7. They shall provide sufficient bath accommodation for all men and women employed.

8. They shall provide dressing rooms, a dining room, lavatories and a cloak room, in which the ordinary clothes of all workers are to be kept apart from their working clothes.

9. They shall arrange for a weekly visit by a doctor, who shall examine every worker individually, and who shall enter the result of each examination in the proper register.

10. They shall cause such a register to be kept, and shall have entered in it the date when each worker commences and leaves employment, and the date when each worker takes a bath.

11. They shall cause every case of illness from lead poisoning to be reported both to H. M. inspector of factories for the district and to the certifying surgeon.

12. They shall cause each man or woman to take a bath at least once a week, and to wash in the lavatory before bathing.

13. They shall deliver to the persons employed the articles of clothing which are required to be worn, and they shall see that they are put on. At the end of every day's work they shall collect and have thoroughly washed all those which have been used in the stoves, and those which have been used in other departments once a week.

14. They shall see that the general lavatory is thoroughly cleansed and supplied with clean towels after every meal.

15. They shall have the dressing rooms, baths and water closets brushed and cleansed daily.

16. They shall not allow the workers to leave any clothes in the dining room, or their ordinary clothes in any work room.

17. They shall see that the supply of hot and cold water, soap, brushes and towels is sufficient in the bathroom and lavatories.

18. They shall see that there are kept in close proximity to the workers in each department washing conveniences and a sufficient supply of approved sanitary drink, and they shall cause the people to take it.

19. They shall set apart, and cause to be entered in a notice affixed in each department, a period of at least ten minutes, in addition to the regular meal times, for washing immediately before each meal time, and also before the end of the day's work; and they shall see that it is observed.

20. They shall see that at the doctor's weekly visit the proper entries are on each occasion made in the register.

21. Upon any person complaining of being unwell, they shall with the least possible delay give an order upon the doctor; and upon any person desiring medicine, they shall give a dose of the prescribed medicine kept at the works.

22. Managers, etc., shall report immediately to the firm any instance which comes under their notice of any worker neglecting the regulations hereinafter mentioned.

23. They shall examine all persons going out of the works, and shall not allow them to leave unless they are properly cleansed from lead.

DUTIES OF PERSONS EMPLOYED.

24. Each man or woman before commencing work in any of the following departments shall wear as follows, having received the same from the person in charge:

Blue beds—Every woman to wear an overall suit in all blue beds where the returns are used without being remelted.

White bed—One overall suit and head covering. Women inside the white beds to wear respirators also, but the "carriers" not.

Washing and Crushing—One overall suit and head covering. "Roller" women to wear respirators also.

Grinding—One overall suit and head covering.

Setting Stoves—One overall suit and head covering.

Drawing Stoves—One overall suit, head covering and respirator.

Paint Mixing—One overall suit and respirator.

25. Each man or woman working at any white bed, or in setting or drawing stoves, or in the washing and crushing, grinding or paint mixing departments, before going to breakfast, dinner or home, or before entering the dining room for any purpose whatever, must—

Put off the overall suit, etc., and give the same to the person in charge, or leave it in the clothes room.

Brush every particle of lead dust from his or her clothes.

Thoroughly wash face and hands in the lavatory, and be particular that no dust remains underneath the finger nails.

If not wearing stockings and boots, thoroughly wash the feet.

26. Each man or woman must bathe at least once a week, and must wash in the lavatory before bathing.

27. Each man or woman must receive and drink, at such times as may be stated in a notice affixed in the factory, such sanitary drinks as may be prescribed in such notice.

28. Every white bed must be adequately watered on removal of the boards, and all trays of corrosions shall be well saturated with water before passing through the rollers.

29. No person shall smoke or use tobacco in any workplace or room, or take food in any part of the works, except in the dining room.

30. No person may seek employment under an assumed name, or under any false pretense.

Respirators—A good respirator is a cambric bag, with or without a thin flexible wire made to fit over the nose.

Sanitary drink suggested: { Sulphate of magnesia, 2 ozs. Water, 1 gallon. Essence of lemon, sufficient to flavor.

Prescribed medicine.

The following departments to be specially ventilated: (1) Washing and crushing. (2) Grinding in water. (3) Paint (grinding in oil). (4) Drawing stoves.

In certain works the following additional self-imposed regulations are enforced:

1. Anyone feeling unwell must report themselves to the foreman, who will see that they are attended to; if taken so unwell as to be unable to come to work, word must be sent at once to the firm, who will pay the cost of a telegram.

2. A doctor will attend the works twice a week, and anyone showing the effects of the lead will have their work changed, or be suspended until recovered. The firm will provide medical attendance free of charge.

3. No person who has been off work through illness will be employed again until passed by the doctor.

4. Certain drinks are provided by the firm, and should always be taken in preference to water. At 6:30 a. m. a free breakfast is provided for stove women only. Acidulated lemonade may be had at any time, but must be taken as follows: 7:50 a. m., 12:50 p. m., 5:30 p. m.

5. Anyone who is supplied with a respirator and not wearing it will be fined or dismissed.

6. Anyone breaking any of the above rules and any of the special rules under the factory act, will be fined 1s. for the first offense, 2s. for the second offense, and for the third offense will be dismissed.

COMMENTS.

Such are the present rules, both official and non-official. As a whole they appear to be the most feasible set that has been formulated by the government, which may largely be accounted for by the fact that almost without exception the government adopted the rules which the manufacturers had of necessity framed for their own protection and to insure the convenient and regular conduct of a difficult process.

Even as matters stand there are some points that present difficulties in working, and we may here mention that our columns are open to the discussion of these and subsequent rules both from the employer's, employe's and inspector's point of view, for without the co operation of these three nothing satisfactory will ever be done.

Rule 4.—This can only be enforced when the person who has been ill has been attended by the firm's medical officer. If, as frequently happens, the man or woman who is suffering does not wish the firm to know of the illness in case of losing employment, they will go to some other doctor, making any excuse for their absence when ready to return to work. The only way to render this rule really effective is to make it compulsory for all doctors to report cases of lead poisoning in the same way that certain infectious diseases are reported. Experience shows that in almost every fatal case there have been previous attacks of which the firm were quite ignorant. In any serious case the person is never employed again. Hence the desire to conceal the fact. The rule as at present drawn is useless.

Rule 18.—Washing conveniences in close proximity to the workers are superfluous. What is the use of washing when the very next minute the hands will be as thickly coated as before? In the opinion of some, frequent washing, especially in warm water, is as bad as, if not worse than, no washing at all, since the pores of the skin are opened.

The sanitary drink found in use was simply water acidulated with sulphuric acid and sweetened with sugar. This makes a most palatable drink, and one that the workers take freely, because they like it. No objection was made to this drink by the Home Office Committee, yet they must suggest one which they consider better. It is so intensely nasty that it is evident the committee could not have tasted this mixture, or they would never have suggested it. The drink must be palatable or it will never be taken.

Substitutes.—In concluding, let it be said that the question of innocuous substitutes is one point which has been definitely settled, and we emphasize it because such a number of ignorant but would-be humane people indulge haphazardly in endless and inane vaporings on this very question, as if therein lay the solution of all the dangers attending white lead manufacture. We cannot do better than quote the exact words of the government committee of inquiry—words that were embodied in their report after hearing and considering pages of evidence for and against: "With regard to these so-called substitutes, the committee have invariably found that on closer inquiry of persons competent to judge and unprejudiced on either side, the substance in question was in some particulars inferior; and they have come to the conclusion that there is at present no substitute that can take the place of carbonate of lead made by the old Dutch process."—Chemical Trade Journal.

[Continued from SUPPLEMENT, No. 1044, page 16690.]

COMMERCIAL FIBERS.*

By D. MORRIS, C.M.G., M.A., D.Sc., F.L.S., Assistant Director of the Royal Gardens, Kew.

LECTURE III.

IV. BRUSH AND MAT FIBERS.

MONKEY BASS.

THE hard, wiry palm fiber obtained from Leopoldinia Piassaba is known as Para Piassava, or monkey bass. The palm, when fully grown, is about 20 to 30 ft. high. The fronds or leaves are feather-winged or pinnate, with rather rigid leaflets. The plant is found abundantly, but less than formerly, in the Amazon basin, especially in Barra de Rio Negro. It grows generally as isolated specimens in dense tropical forests, but is found sometimes in patches of several trees together. It is nowhere cultivated. The dilated margins of the petioles, where they clasp the stem, are produced into long riband-like strips, which afterward split into fine, somewhat round fibers, about 5 or 6 ft. long, entirely concealing the stem. These fibers, cleaned and combed by hand, form the piassava of commerce. There is very little preparation necessary after the fiber is collected in the forest. It is used for making brooms and brushes. Owing to the discovery of other sources of piassava, and to the palms becoming scarcer in accessible situations, Para piassava at present forms only 4 or 5 per cent. of the total fiber found in commerce. Para piassava usually commands high prices.

FIG. 14.—MONKEY BASS (LEOPOLDINIA PIASSABA).

Transverse section of a single strand of monkey bass, apparently composed of three or more fibro-vascular bundles coalesced together. The empty spaces represent the position of the vascular bundles. × 82.

BAHIA PIASSAVA.

A large, handsome palm, with pinnate leaves (Attalea funifera), abundant in the province of Bahia, Brazil, on river banks and moist situations, yields a fiber very similar to the monkey bass of Para. The bases of the leaf stalks separate into a long, coarse fringe, containing somewhat flat, flexible fibers. The trees grow wild and no care is taken to preserve them. They are often cut down altogether in the young state for the convenience of getting the fiber. The latter is removed from the trees by means of a small ax. It is then "roughly heckled, straightened, cleaned, and made up into bundles of about 32½ pounds each." The annual export from Bahia is about 7,000 tons, of the value of £117,664. Great Britain takes slightly more than one-half. The cost of the fiber delivered at Bahia is estimated at 5s. 7d. per arroba (32½ lb.) The fruits of this palm are the Coquilla nuts of commerce, used for turnery purposes. An interesting account of Bahia piassava is given by Mr. W. S. Booth in the Kew Bulletin, 1889, pp. 237-242.

MADAGASCAR PIASSAVA.

For many years a long, fine fiber, of a rich brown color, has been obtained from Madagascar closely resembling Para piassava. The plant was only determined last year, when it was described in the Kew Bulletin, 1894, p. 358. It is Dictyosperma fibrosum,

* Lectures before the Society of Arts, London, March, 1895.—From the Journal of the Society.

known locally as Vonitra. The fiber is finer and more flexible than Brazilian piassava. The quantity received in this country has always been limited, and latterly it has almost entirely disappeared. The high quality may be gathered from the fact that the last prices paid were £46 6s. per ton, with "good to prime" Bahia at £40 to £50 per ton, and "good" Palmyra at £30 to £40 per ton. When well cleaned, Madagascar piassava took rank as a first-class brush fiber.

WEST AFRICAN BASS.

In 1890, Sir Alfred Moloney, then governor of Lagos, drew attention to the possibility of obtaining a fiber from the bamboo or wine palm of West Africa. This is Raphia vinifera (already mentioned as likely to yield epidermal strips similar to Madagascar Raffia). The bamboo palm extends throughout many parts of West Africa. In Lagos alone it is estimated that it forms a considerable proportion of the forest vegetation over an area of 5,000 square miles. The fiber is obtained from the fibrous sheathing at the base of the petioles. It is readily obtained in lengths of 3 to 4 feet; the diameter of the individual fibers as found in commerce is from $\frac{1}{12}$ to $\frac{1}{18}$ of an inch. To understand the mode of occurrence of the fiber, the following is taken from Sir Alfred Moloney's account, published in the Kew Bulletin, 1891, p. 4: "When the leaves are cut away from the lower part of the palm, portions of the leaf stalk are left adhering to it. These leaf stalks incase the trunk, and project upward and outward, forming chevaux de frise all round it. From the fiber in these stumps the native fishing lines are made. It is extracted by simple soaking in water and scraping. The process is very simple and fully understood by the natives. It is the stronger portions of this fiber which are exported as West African bass." The governor adds, "There is no reason why, with a population in the habit of preparing it, and a source of supply which may be regarded as practically unlimited, we should not be able to compete on even terms with the sources of supply which at present monopolize the market." Since 1890, West African bass has become a

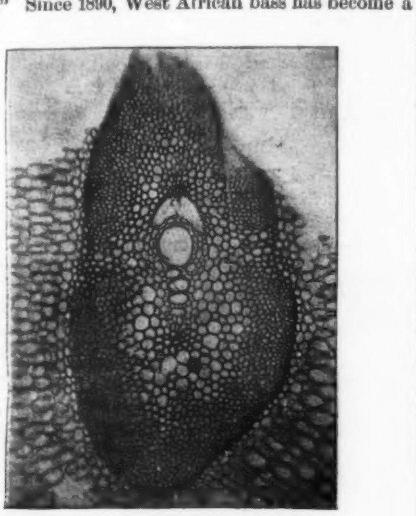


FIG. 15.—WEST AFRICAN BASS (RAPHIA VINIFERA).

Transverse section of a single fibro-vascular bundle of West African bass, partly embedded in cellular tissue. The vascular portion in the center occupies a large proportion of the area, and thereby tends to weaken the character of the fiber. × 50.

regular article of commerce. The prices are usually below Para and Bahia fibers. At the beginning of 1895 "the arrivals were heavy; prices £12 to £26 per ton."

PALMYRA FIBER.

A fiber very similar to West African bass, and nearly of the same character as Para and Bahia piassava, is obtained from the Palmyra palm, called by the Portuguese, par excellence, "palmeira," or "the palm tree" (Borassus flabellifer). In West Africa it is known as the Black Run palm. It is very tall, sometimes, but very rarely, branched, with large, fan-shaped leaves with spinous petioles. The fruit is nearly as large as a cocoa nut, with one to three seeds. The Palmyra palm is widely distributed in India and Ceylon, but generally in a cultivated state. It is, however, truly wild in tropical Africa. In the East it is a toddy or sugar palm. The young germinating nuts are cooked and eaten as a vegetable. The leaves are made into books, which contain the classics of the Pali and Singhalese languages. The timber is hard, and very durable; it is used for umbrella handles and walking sticks. From the base of the petioles, or the sheathing leaf stalks, is obtained a stiff, wiry fiber. This was at first called "bassine," to distinguish it from bass and piassava fibers. It came into notice as a commercial article in 1891, when the high prices of piassava induced the production of substitutes. At that time even split rattan, stained black, was requisitioned as a brush fiber. Palmyra fiber has steadily increased in quantity, and, contrary to what was at first anticipated, it has also risen in value. "The chief objection to Palmyra," wrote Messrs. Ide and Christie, in 1892, "is that it lacks straightness, but experiments are being made in this country to overcome this defect, and should they prove successful, it is claimed by importers and dressers that Palmyra should, for wear, be found equal to the best Para." These anticipations have, to some extent, been realized. Palmyra now has practically taken the place of West African bass. The latter, on the 16th September, 1895, was "dull, business small, £14 to £23 per ton." Palmyra fiber, on the other hand, was "good, £26 to £34; medium, £22 to £25; common, £15 to £19 per ton."

The natives in Ceylon and India are evidently copying the worst practices of the Indians of Brazil in sending consignments of Palmyra fiber to this country in a damp condition. The result is that, as one firm complains, "the bales, on opening, are found wet, and the fiber to a large extent perished and powdery." Should the practice continue, the industry will be seriously injured. The bales are press-packed, and

FIG. 16.—PALMYRA FIBER (BORASSUS FLABELLIFER.)

Transverse section of a single fibro-vascular bundle of Palmyra fiber. The vascular area is small, hence the greater strength of the bundle. The fiber cells are densely compacted, very numerous, and with thick walls. The durable character of Palmyra fiber is therefore evident. × 80.

iron bound; they weigh 1 to 3 cwt., and measure 10 to 30 cubic feet.

KITTOOL FIBER.

The kittool or kittul palm of India and Ceylon (Caryota urens) is a stout handsome plant with a smooth annulated stem, 30 to 40 feet high. It has broad leaves, with the leaflets obliquely cuneate. The fruit is small and reddish. It is a toddy and sugar palm, and also yields sago.

Mr. J. R. Jackson, A.L.S., in "Commercial Botany," gives the following excellent account of the fiber yielded at the bases of the leaves of this plant: "Kittool fiber," he says, "has been known in this country for some thirty or forty years, but it is within the last ten years that it has become a regular commercial article. When first imported, the finer fibers were used for mixing with horsehair for stuffing cushions. As the fiber is imported, it is of a dusky brown color; but after it arrives here it is cleaned, combed, and arranged in long straight fibers, after which it is steeped in linseed oil to make it more pliable; this also has the effect of darkening it, and it becomes, indeed, almost black. It is softer and more pliable than piassava, and can consequently be used either alone or mixed with bristles in making soft, long handled brooms, which are extremely durable, and can be sold at about a third the price of ordinary hair brooms."

The use of kittool fiber is said to be spreading not only in this country, but also on the Continent. During 1895 kittool fiber has not been much in demand. The values on September 16 were quoted as follows: "Long, 10d. to 10½d.; No. 1, 7d. to 7½d.; No. 2, 3d. to 2½d.; No. 3, 1d. to 1½d. per lb."

EJOO, OR GOMOTU FIBER.

An erect palm, with pinnate leaves, the sago palm of Malacca (Arenga saccharifera), is found plentifully in Burma and the far East. At the base of petiole is found a beautiful black fiber, know as Ejoo, or Gomotu fiber. There are several qualities: the coarsest is only fit for brush making; the medium qualities closely resemble black horse hair, and make excellent ropes and cables; the finest are used for calking ships, stuffing cushions, and as tinder. Ejoo fiber is extensively used in the East. It undergoes no preparation, either before or after being twisted into ropes. It is remarkable for quality and cheapness, and is so durable under water that it has been recommended as a covering for telegraph cables.

COCOANUT FIBERS.

The cocoanut palm (Cocos nucifera) is extensively cultivated in nearly all tropical countries. It exists in immense groves in Southern India, Ceylon, the islands of the Eastern Archipelago, and Polynesia. Its cultivation is extending in the West Indies and on the East and West Coasts of tropical Africa. The cocoanut palm is one of the first objects to be seen along the beach, and soon becomes one of the most familiar objects to travelers in the tropics. It is a valuable food plant for man and animals, and provides besides materials for the construction of houses and numerous utensils in daily use. It has a cylindrical stem, usually gracefully curved, and attaining a height of 40 to 100 feet, surmounted with a crown of large feathery leaves. The plant is propagated by means of seed nuts (the fruit); these germinate, if kept moist, in three to five months. The young plants are put out in their permanent places, when about eight to fifteen months old, at distances varying from 27 to 33 feet apart. The cocoanut begins to bear in five to eight years. Usually the nuts take from eight to ten months to mature before they fall from the parent plant. Each cocoanut palm bears from thirty to sixty, and very exceptionally, when well watered and manured, up to 100 nuts a year.

As shown above, the coir of commerce is yielded by the thick pericarp or outer fibrous covering of the fruit of the cocoanut palm. The word "coir" is said to come from the Malay Káyar, a twisted product. Káyar is also the Tamil for a rope. Although coir was known in Europe in the sixteenth century, it was not until about 1842 that it was brought prominently into notice. St. George's Hall, Windsor, in that year was laid with cocoanut matting on the occasion of the baptism of the Prince of Wales. Later a great impetus was given to coir manufacture by the Great International Exhibition of 1851.

Cocoanut fiber is tough, elastic, easily manipulated

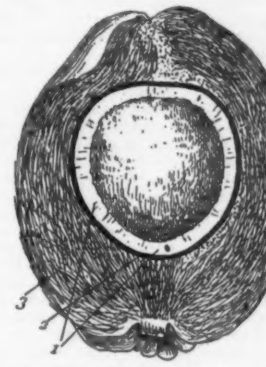


FIG. 17.—COCOANUT (COCOS NUCIFERA).

Vertical section through the fruit of a cocoanut palm. The central cavity contains the milk. 1, the white albumen or flesh of the cocoanut; 2, the endocarp or brown, hard, bony shell; 3, the pericarp forming the fibrous covering or husk of the cocoanut; this yields the coir of commerce. At the termination of the lower line 1 is the embryo pointed toward the base of the fruit. [In planting the cocoanut in the nursery it is, therefore, necessary to place it with the basal or stalk end uppermost.] ½ n. s.

within certain limits, and eminently suitable for manufactures where lightness, cleanliness, and great indestructibility are required. It is understood that cocoanut fiber will not bear bleaching. Various shades of color are, however, obtainable by using different descriptions of natural unbleached fiber. In an ornamental mat in the Kew Museum the various shades are obtained by using dark Fiji coir, medium colored Ceylon coir, and very light Cochin coir.

Besides being made into rough cordage, coir is used in combination with wool to give richness and effect to hearth rugs and carpeting. It is also used for brushes and brooms for household and stable purposes, matting for sheep folds, pheasantries and poultry yards, church cushions and hassocks, hammocks, clothes lines, cordage of all sorts, string for nurserymen, nosebags for horses, mats and bags for seed crushers, oil pressers, and candle manufacturers. Coir is one of the best materials for cables, on account of its lightness, elasticity, and strength. It is durable, and little affected by salt water. Of coir and coir made rope, about 9,000,000 to 10,000,000 lb are annually shipped from India; much is prepared in Ceylon; but Cochin is noted as the port of shipment for the best quality of yarns.

Certain varieties or cultivated forms of the cocoanut are better suited than others for the production of coir. Cochin (a small native state on the Malabar coast) produces a bright, light colored coir, which fetches the best price. On the other hand, a good deal depends on the age at which the nuts are gathered, and the time which elapses before they are husked and cleaned.

In the process of separating the fiber, the following commercial qualities are produced: The mat or long fibers, used for spinning purposes; the shorter, or

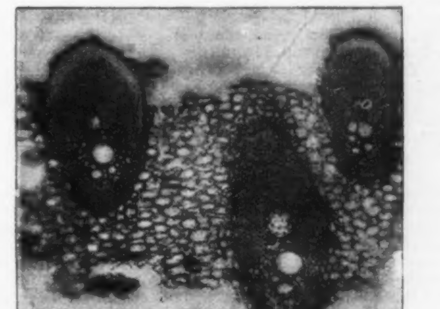


FIG. 18.—COCOANUT (COCOS NUCIFERA).

Transverse section through a portion of the fibrous husk (pericarp) of the cocoanut. Three fibro-vascular bundles are shown embedded in cellular tissue. Each bundle represents single fiber of coir when thoroughly isolated from the cellular tissue. There is a considerable resemblance in character, but not in size, between the fibro-vascular bundles in the husk of the cocoanut and those in the petioles of the Palmyra palm (Fig. 16). Hence, probably, the durable character of the latter. × 50.

more stubborn fibers (bristles), for brooms or brushes; the tow or curled fiber for stuffing cushions; and the dust or refuse for gardening purposes. When dyed black the tow has been used as a substitute for horse hair. A singular use was proposed a short time ago for cocoanut dust or refuse. Taken before it is quite dry, and subjected to great pressure, it is capable of forming plates of varying thickness, like mill board, only much more brittle. These boards, if used as backing for steel plates of ironclads, swell up on being punctured below the water line, and soon close the orifice. If really effective, such plates could be produced at a trifling cost, for thousands of tons of cocoanut refuse float away annually down the rivers in India and elsewhere.

The first step in the preparation of coir is the removal of the husk from the hard interior shell. This is usually done by striking the nut on a pointed instru-

ment stuck in the ground. A man can husk about 1,000 a day. The husks are then soaked in water. This is variously conducted. The water may be either salt, brackish, or fresh; in this the husks are kept for a lengthened period. The more recent method is to place them in tanks of water made warm with steam. The latter hastens the softening process, and improves the color and quality of the fiber. Where machinery is used, the husks, when sufficiently soaked, are passed through a crushing mill, which flattens and crushes them ready for the extractor, or breaking down machine. In the latter the fibers are completely disintegrated, and are then passed through a "willowing" machine, to free them from dust and refuse. It is calculated that when treated in this country, 10,000 husks will produce 45 to 50 cwt. of "spinning fiber" and 9 to 13 cwt. of "brush fiber."

In Ceylon, 40 cocoanuts are said to yield 6 lb. of coir; in Madras, 3 large coast nuts yield 1 lb. of coir; in the Laccadives it requires 10 small nuts to yield a pound of coir, measuring, when made into yarn, 35 fathoms. In 1889, an attempt was made to export coir from Lagos. A bale of loose coir, weighing 42 lb., was prepared from 400 nuts. No attempt had been made to separate the "bristle" and "mat" fibers. Good Ceylon bristle fiber was then worth £30 per ton and Ceylon mat fiber £10 per ton. The Lagos fiber, when separated, was valued at £15 and £9 to £10 respectively (Kew Bulletin, 1889, pp. 122-132). The average annual value of coir goods exported from Ceylon is put down at £60,000. The quantity exported in 1884 was as follows: Coir rope, 10,419 cwt.; coir yarn, 84,057 cwt.; coir fiber, 12,732 cwt.; total, 107,208 cwt.

The principal exports of coir from India are from the Madras Presidency. For the five years ending 1880-81 they were 271,934 cwt., valued at Rs. 2,179,767, while for the year 1881-82 the value was Rs. 2,354,202. The exports from the Malabar coast alone amounted to Rs. 2,243,000. "From these figures an idea may be obtained of the immense importance of Malabar and the Laccadives as the chief seats of the Indian coir industry."

The approximate market value per ton of coir goods in London on September 16, 1895, was as follows:

Coir yarn: Cochin, common to good, roping, £11 10s. to £14; weaving, fair to good, £20 to £25; Ceylon, fair to good, ballots and bales, £17 to £21.

Coir fiber: Cochin, fair to good, £14 to £20; Ceylon, clean, £8 to £9 10s.

Coir rope: 4½ to 6 inch, 2½ to 3½ inch, and 1¾ to 1¾ inch, £11 to £14.

Bristle fiber: Medium, £18 to £21; good, £29 to £30.

BLACK CURLED FIBER.

The only palm native of Europe is the Dwarf Fan Palm (Chamærops humilis). This is the French Palmier de Nain. It is very abundant in North Africa, and particularly in the departments of Algiers and Oran. It forms extensive thickets in the dry alluvial soils of the littoral, and is very difficult to eradicate in any land where it is established. Once regarded as a troublesome and useless plant, it has of late years become a source of profit and commerce. The leaves furnish 50 per cent. of fiber, which is extensively used as a cheap substitute for horse hair. A man can cut about 400 lb. of green leaves per day. The fiber is extracted either by combing by hand or by means of drums with needles and knives worked by steam power. The "green" fiber is twisted or curled in its raw state, and finds several applications. The "black" fiber is first dyed in baths of sulphate of iron and logwood; it is then twisted and again dyed. The local name is crin végétal. This fiber is said to possess two advantages over animal fiber, and these have led to its extensive employment. It is exempt from insect destruction, and 75 per cent. cheaper than horse hair. There are large works in Algeria where the leaves are brought in large quantities, and the fiber cleaned on an extensive scale. "In Oran one factory prepares daily 60 bales of 2 cwt. each." In another, "by a particular process, a firm prepares black and brilliant crin végétal, without smell or dust, at the rate of 1,000 cwts. per month." The fiber is consumed principally in France, England, Germany, and the United States.

"The quantity of this vegetable hair shipped from Algiers in 1872 was 2 394,000 kilos. In 1887 the exports were as much as 15,304,126 kilos, valued at £88,900." The price of "black curled" fiber on September 16, 1895, was 9s. 6d. per cwt.; of "green," 6s. per cwt.

SPANISH MOSS.

Another "vegetable hair," more commonly known in the Southern States of America as Spanish moss, is obtained from a delicate, mossy looking plant (Tillandsia usneoides), belonging to the pineapple family. This grows as an epiphyte on trees in tropical and subtropical parts of South America, the West Indies, and the Soutnern United States bordering on the Gulf of Mexico. In the West Indies it is called the "Old Man's Beard." The plant hangs in loose, lace-like masses on the branches and stems of several kinds of trees. The largest and most tenacious is said to be gathered from the cypress (Taxodium distichum). It gives these quite a funereal aspect. A living plant of this Tillandsia suspended from a dry block, and apparently deriving all its nourishment from the atmosphere, may be seen in the Tropical Stove (No. 9) at Kew. The "moss" is gathered in the Southern United States by negroes, who afterward sell it to the factories, where it is cleaned and made into fiber. The single thread or fiber contained in the stem and leaves of this interesting plant is tough and black, almost identical with horse hair. The fiber is prepared by soaking the plants in water until the cuticle of the leaf has decayed. It is then boiled in water, and washed until the black fiber is perfectly clean and glossy. It may also be prepared by simply burying the moss in earth for two or three weeks, and then washing in water. When well prepared, this fiber is not only frequently used instead of horse hair, but is almost indistinguishable from it. It is largely used for stuffing purposes. The headquarters of the industry is at New Orleans.

PINE WOOL.

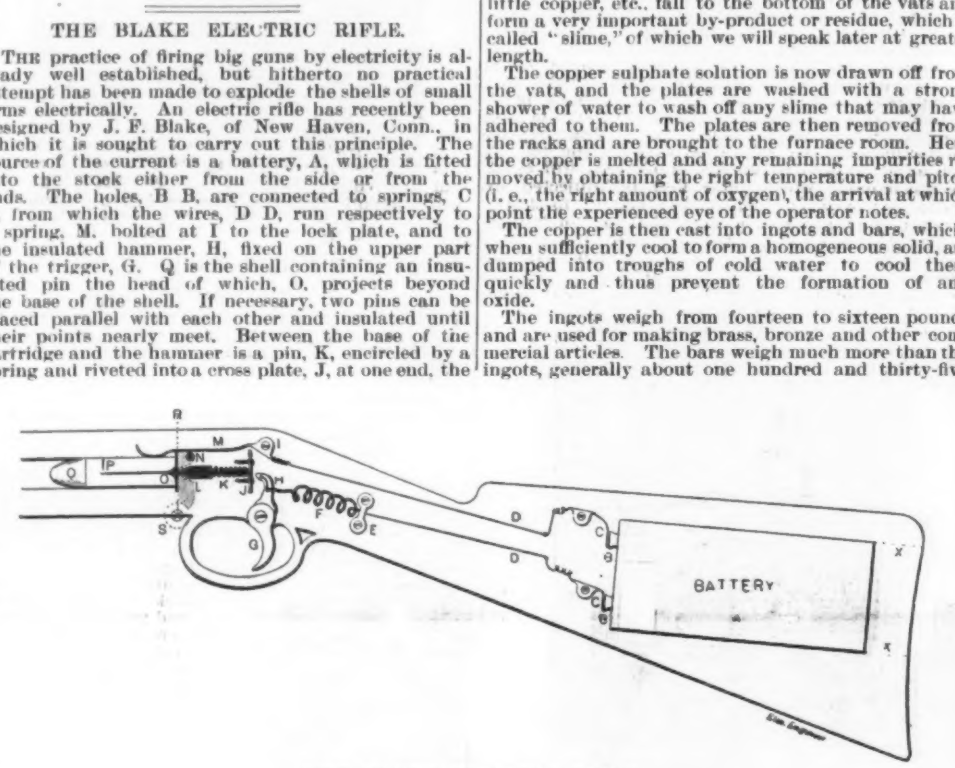
A brown elastic fiber is prepared in Germany, and in some parts of the United states, from the leaves of pine trees. In Germany the leaves are obtained partly from what is known in this country as the Scotch Fir (Pinus sylvestris) and partly from the Corsican Pine (P. Laricio). In the United States the leaves of the long-leaved or Resin Pine (Pinus palustris) are chiefly used. The industry was started at Breslau about thirty years ago. The pine leaves are collected in the fresh state and delivered at the factory at a fixed price per cwt. They are spread out and carefully picked over to get rid of portions of twigs and bark. They are then placed in a still with water to extract the oil, which forms an important item in the industry. This oil has the characteristic odor of pines. It is at first green, then yellow. There is a considerable demand for pine oil in commerce. The leaves, when removed from the still, are boiled with alkalies, broken in a "rubber," and dried. The fiber is then curled, passed through carding machines, and once more dried. The yield of "pine wool" is 13 per cent. of the weight of the green leaves. True "pine wool" is said to retain the odor of the pine, is soft in texture, elastic and durable. It is recommended as a surgical dressing; the finer sorts are used for making wearing apparel and blankets, and the coarser for carpets or mats.

A good deal of the material advertised as "pine wool," "fir tree wool," and "pine forest wool," has been proved to be nothing more than cotton or sheep's wool stained of a brown color to resemble the genuine article.

(To be continued.)

THE BLAKE ELECTRIC RIFLE.

THE practice of firing big guns by electricity is already well established, but hitherto no practical attempt has been made to explode the shells of small arms electrically. An electric rifle has recently been designed by J. F. Blake, of New Haven, Conn., in which it is sought to carry out this principle. The source of the current is a battery, A, which is fitted into the stock either from the side or from the ends. The holes, B B, are connected to springs, C C, from which the wires, D D, run respectively to a spring, M, bolted at I to the lock plate, and to the insulated hammer, H, fixed on the upper part of the trigger, G. Q is the shell containing an insulated pin the head of which, O, projects beyond the base of the shell. If necessary, two pins can be placed parallel with each other and insulated until their points nearly meet. Between the base of the cartridge and the hammer is a pin, K, encircled by a spring and riveted into a cross plate, J, at one end, the other end being fitted into an insulated thimble, L, the point of which nearly touches the shell pin head, O. When the cartridge has been inserted and the gun closed, the spring, M, rests on the metal base of the cartridge.



THE BLAKE ELECTRIC RIFLE.

As the trigger is pulled, the hammer strikes the plate, J, forcing the point of the thimble, L, into contact with the projecting end, O, of the cartridge pin. An arc is established at P O, which explodes the contents of the cartridge.

The point of the firing pin, P, can be placed anywhere within the explosive powder of the cartridge, but by extending it near the bullet, as shown in the illustration, a more effective explosion of the powder is secured.—Electrical Engineer.

COPPER REFINING BY ELECTRICITY.*

By H. C. GARNEAU.

THE problem of the cheap and rapid refining of copper has been solved by that almost universal agent, electricity. The fact that copper can be purified by deposition by means of a galvanic current has long been known, but its practical application to commercial uses is something we owe to these latter days. Its commercial application has shown that it is the cheapest and best method by which to recover and save those valuable impurities in copper, if we may call them impurities, gold and silver.

The ores of Michigan, Calumet and Hecla, contain a comparatively small amount of gold and silver, whereas in those of Montana, as the Anaconda ores, these precious metals cut quite a figure. As the Anaconda ores come nearer the ideal than any other native ores for electrical refining, we will take them as the example in the description following.

All the preliminary smelting is done at the mines, and consequently the copper as received at the refining works is in a comparatively pure state. It is received in plate bars, having dimensions in feet of about 1·5 × 1 × 0·5. These plates, weighing about one hundred and twenty-five pounds, are placed in furnaces, where they are heated to a bright redness. When they have reached the desired temperature they are rolled in return rollers (generally of five sizes) until the plates are about twenty-three feet long, one inch thick and one foot wide. As this strip of metal goes out of the last roll it is passed through a trough of cold water to cool it quickly and thus prevent the formation of any oxide as an impurity and a loss. These strips are then cut into small plates about a foot and a half long and one foot wide; the rough edges are also cut off, and when sufficient scrap accumulates it is reheated and rerolled.

Two of these small plates are put in suitable grooved wooden racks, which may be used over again two or three times.

These racks, when filled, are brought to the electrical depositing room. This is a large room containing vats in series, each vat having a capacity of fifteen to twenty plate racks. There are generally twenty vats to a series, but the number varies. These vats are filled with a solution of medium strength of blue vitriol, sulphate of copper, which acts as a carrier for the copper in process of deposition. The copper sulphate solution is constantly kept moving and renewed by hydraulic pumps at the end of each series of vats and by means of a system of pipes and gutters.

The racks are now placed in these vats and electric wires attached. The current from the adjoining dynamo room is turned on and the copper begins to deposit from the positive to the negative side, or vice versa, according to the direction of the current. This deposition is allowed to go on unwatched for a period of fourteen days, at the end of which time the copper plates have completely redeposited themselves and the copper is almost pure. While the deposition is going on the impurities, as gold, silver, sulphur, dirt and a little copper, etc., fall to the bottom of the vats and form a very important by-product or residue, which is called "slime," of which we will speak later at greater length.

The copper sulphate solution is now drawn off from the vats, and the plates are washed with a strong shower of water to wash off any slime that may have adhered to them. The plates are then removed from the racks and are brought to the furnace room. Here the copper is melted and any remaining impurities removed by obtaining the right temperature and pitch (i. e., the right amount of oxygen), the arrival at which point the experienced eye of the operator notes.

The copper is then cast into ingots and bars, which, when sufficiently cool to form a homogeneous solid, are dumped into troughs of cold water to cool them quickly and thus prevent the formation of any oxide.

The ingots weigh from fourteen to sixteen pounds and are used for making brass, bronze and other commercial articles. The bars weigh much more than the ingots, generally about one hundred and thirty-five pounds, and are used in wire mills for making trolley and other varieties of copper wire.

Treatment of the Slime.—In copper containing gold and silver the treatment of the slime is one of the most, if not the most important part of the refining, for out of it we recover the precious metals, gold and silver. In fact, it is said that the recovery of the gold and silver pays for the running of a refinery and the copper represents the profit.

The slime is treated as follows: It is first scraped from the bottom of the vats and put into "slime barrels," in which it is taken to the "slime house." This is a building, generally of three or four stories, where the slime starts from the top floor and, being purified in its descent, appears at the bottom as bars of silver and gold.

The "slime" is first made of a thin, mud-like consistency. It is then run into a swiftly revolving centrifugal, which has inside a forty-mesh sieve. This sieve allows all the gold and silver, some dirt and a little finely divided copper to pass through, while it retains the wooden chips (from the racks and vats), most of the dirt and copper (as small slivers and scales). That which is retained is rejected, while that which passes through is run into a vat, where it is boiled by steam with a five per cent. solution of oil of vitriol; it is treated thus until all the copper is dissolved as copper sulphate, the solution of the vitriol being too weak to dissolve any silver as silver sulphate. This, with the gold, settles to the bottom in its elementary state. The mass is then filtered on coarse cloth or canvas filters and then washed two or three times to free it of copper sulphate and dirt. The residual silver and gold are cast into bars, which, however, contain copper and other impurities. These bars are then dissolved in sulphuric acid, the silver going into solution as silver sulphate; the gold unacted upon by acid falls to the bottom of the vat in a finely divided state. It is then gathered up, filtered and washed free of silver sulphate, etc.; it is then dried on pans, and when sufficient has accumulated is cast into bars.

The silver is recovered by putting into the solution bars of copper. The copper being more electro-positive than the silver, supplants it in the solution of the sulphate and the free silver deposits on the copper bars. This reaction is allowed to go on until all the silver is deposited or until the solution gives no white precipitate (silver chloride) with a drop of hydrochloric acid. The free silver is then filtered and washed free of copper sulphate. It is finally dried on pans and cast into convenient bars. Thus the silver and gold are recovered.

* From the Yale Scientific Monthly.

ALFRED E. BEACH.

OUR readers will look in vain at the heading of our editorial pages for a name that has appeared there ever since our publications were started. The present number of the SUPPLEMENT is the last that will be issued under the able editorship of Mr. Alfred E. Beach. This paper was started just twenty years ago and it was his particular work of love. He closed the volume, folded his hands, and finished his work with the dying moments of the old year and he awoke to find the new year begun in another and better land, free from care, turmoil, and responsibility. He will no longer engage in the labors of this office, where he has worked so assiduously for so many years; but the remembrance of his spirit and his life work will remain as an everlasting guide and inspiration to his successors.

STEAM PIPE ISOLATING VALVE.

WE illustrate herewith a simple arrangement of isolating valve, constructed by Messrs. Schäffer and Budenberg, of Southgate, Manchester, for use in connection with steam pipes as a precaution against the escape of any large quantities of steam in the event of a pipe bursting.

In accidents of this kind the greatest damage is generally done, not so much by the explosion itself, as by the immense volumes of steam and water which are poured forth by the broken pipe, threatening the most fearful danger to human life in the vicinity, the risk being aggravated where these accidents occur in confined situations. By careful supervision the risk of such accidents may be greatly minimized; still, cases are unavoidable where pipes may be subjected to strains they were not originally calculated to stand, owing to the bending, in time, of the pipes, or in consequence of expansion by heat.

The valve shown in Figs. 1 and 2 is intended to automatically cut off the steam communication from the boiler in case of such accidents. This valve contains a ball, which, in ordinary working, rests at the bottom of the casing. In the event of a pipe bursting, the sudden reduction of pressure on the outlet side of the valve will produce a rush of steam, which sweeps the ball along with it, and forces it against the seating, thus

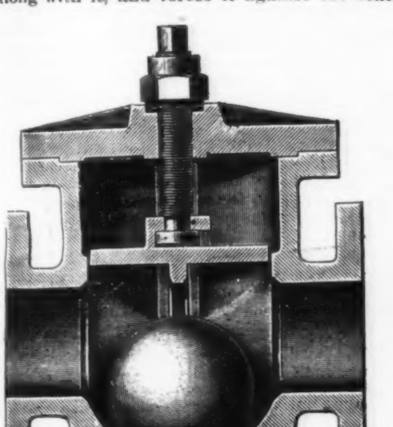


FIG. 1

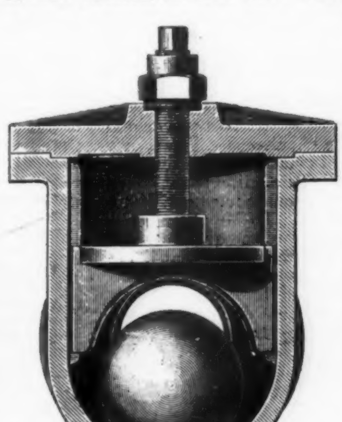


FIG. 2.

preventing any further escape. There is a seating provided for the ball at both outlets, enabling the valve to act either way.

The sensitiveness of the valve depends upon the area of the free passage past the ball, and an arrangement is provided for adjusting the area of this passage to allow of giving any desired degree of sensitiveness to the valve. For this purpose a plate with semicircular opening is arranged across the passage in the center of the valve, and the distance between the ball and this plate can be regulated by turning the screwed spindle shown in the illustrations. The valve is proportioned so that in the highest position of this plate the ball would still close against the seating in case of a complete fracture of the pipe.—Practical Engineer.

AIR BRAKE EQUIPMENT.

AT the November meeting of the New England Railroad Club Mr. R. A Parke, of the Westinghouse Air Brake Company, read a paper upon the subject of "Air Brake Equipment and its Application to Rolling Stock." The paper opened with a narrative of the development of air brakes and the effect of the discoveries which were made at the Burlington brake trials upon the present state of the art was outlined. The chief points of interest in the paper are given in the following abstract, for which we are indebted to the Railway Review.

The remarkably fast time which has become an established element in practical passenger service within the past three or four years has, however, developed a demand for even a better stopping efficiency than that assured by the ordinary quick-action brake, and this requirement has instigated a modification of the quick-action brake apparatus which decreases the length of stops from high speeds about 25 per cent. As no description of this modification has been published, and as its importance to the safety of fast trains is becoming liberally recognized, a brief sketch of the features peculiar to the apparatus will be given, before a general view of present air brake practice is undertaken.

It has long been known that, while practically the same frictional resistance to the rotation of the wheels is required at all speeds to induce them to slide upon a dry rail, the same brake shoe pressure produces much more friction at low speeds than at high speeds. It has therefore been customary to so limit the maximum brake shoe pressure that the friction developed at low speed shall not be sufficient to cause injurious wheel sliding. The total friction at any instant is the direct measure of the resistance which is then retarding the motion of the train, and a uniform brake shoe pressure therefore offers much less resistance to the motion of the train at the high speed in the beginning of a stop than at the low speed toward the end. It is evident that a much greater brake shoe pressure could be employed at high speed than at low speed without sliding the wheels, and this is the purpose of the modification of the quick action brake which is now known as the "high speed" brake.

The high speed brake is essentially a quick action air brake operating under a high air pressure. In emergency applications it creates at first a high brake cylinder pressure which is gradually and automatically reduced to 60 lb. while the speed is being reduced, and in service applications it limits the cylinder pressure to 60 lb. These results are effected by the use of an automatic relief valve which is attached to each brake cylinder and consists of a piston, a slide valve and an adjustable spring. The spring is so adjusted that the valve is inoperative when the air pressure in the brake cylinder is 60 lb. or less. If after the cylinder pressure has reached 60 lb. the supply of air to the cylinder continues, but with no greater rapidity than occurs in any service application of the brakes, a large port in the relief valve is opened and permits the excess supply of air to freely discharge from the brake cylinder, to the atmosphere, so that no increased cylinder pressure occurs. In an emergency application of the brakes, however, the air is supplied to the brake cylinder so rapidly and in so much greater volume that the pressure rapidly rises above 60 lb. and causes a longer travel of the relief valve piston, whereby the large port of the relief valve merely opens and instantly closes again, and the air is caused to escape from the cylinder to the atmosphere through a more restricted port until the pressure has been thus reduced nearly to 60 lb. When the pressure becomes reduced to 60 lb. the further escape of air is cut off and that pressure is retained in the brake cylinder until the brakes are released from the locomotive.

As locomotives which haul high speed trains are generally also used in other kinds of service, it may be frequently necessary to change from the standard train pipe pressure of 70 lb. to the high pressure and vice versa. In order that this change may be quickly effected, the feed valve attachment of the engineer's brake valve is removed and replaced by a flanged fitting, from which two small pipes lead to a bracket under the running board. This bracket supports two feed valves, the one set at 70 lb. pressure and another set for the higher pressure, and contains a three-way cock by which either feed valve may be used as required. The pump governor is also supplied with a Siamese and two diaphragms, one set at 90 and the other at 120 lb. The small air pipe leading from the main reservoir to the 90 lb. diaphragm of the pump governor is supplied with a cock which is opened when a main reservoir pressure of 90 lb. is used, and closed when the higher pressure is required. Of course if the locomotive is used exclusively to haul trains equipped with the high pressure relief valves, the ordinary arrangement of the engineer's brake valve and pump governor fulfills the requirements by merely adjusting them for the higher pressures. The train pipe pressure used with the high speed brake is from 100 to 110 lb.

Experimental tests of the high speed brake have demonstrated the importance of the use of sand on the rails in all emergency stops. Not only is a better stop made, but in case of a bad rail the use of sand is practically a necessity to prevent the wheels from sliding with the high cylinder pressure employed. It is highly desirable that the application of sand should be automatic, so that the movement of the handle of the engineer's brake valve is all that will be required of the engineer in emergencies. The reasons for this are the same ones that condemned the use of a separate operative valve for the driver brake, when it was formerly employed as an emergency appliance. It is therefore urgently recommended that, in all cases where the high speed brake apparatus is applied, a track sanding apparatus shall be used which will operate automatically in every emergency application of the brakes.

Besides shortening emergency stops about 25 per cent., another important advantage in the use of the high speed brake is the ability to make more than one effective application of the brakes without recharging. The importance of this feature in fast train service was well illustrated by an incident which occurred some months ago. A train equipped with the ordinary quick action brake was running at the rate of about 65 miles per hour when the engineer observed a block signal set against him. He had hardly obtained a full service application of the brakes before the signal cleared and he released them.

The speed had not been perceptibly reduced, but the air pressure in the auxiliary reservoirs had been reduced to 50 lb., and before it could be restored the train rounded a curve just beyond the block signal tower, and the engineer encountered a drawbridge signal at danger. An emergency application of the brakes was promptly effected; but when the train stopped the locomotive was within ten feet of the open draw. That train is now equipped with the high speed brake, and it is found that immediately after a full service application and release, there is still sufficient air pressure to make a considerably better emergency stop than could at any time be made with the ordinary quick action brake.

Still another advantage of the high speed brake is the positive limitation of the brake cylinder pressure to 60 lb. in all service applications, regardless of the train pipe pressure used. Although the brake leverage is such that a cylinder pressure of 60 lb. produces a 90 per cent. braking power, and this braking power is available in full service applications, not a single pair of wheels is reported to have been removed from the Empire State Express trains on account of flat spots during the two years that those trains have been equipped with the high speed brake apparatus.

An influential factor in the improved stopping efficiency under present air brake practice is the general use of brakes upon the driving wheels of locomotives. It is but a few years since a large majority of railroads either used no driver brakes at all or applied them for use as an emergency appliance only. It is the present practice of nearly every railroad in the country to make the driver brake just as much a part of the regular train brake equipment as the brakes upon the cars, and serious attention has been given to the fact that upon most engines something more than the driver brake is required to make an effective engine brake. The proportion of the weight of locomotives which is sustained by the drivers may be roughly stated as follows: For eight wheel engines, 65 per cent.; for ten wheel engines, 75 per cent.; for mogul engines, 85 per cent.; for consolidated engines, 90 per cent.

The driver brakes of consolidation and mogul engines are generally very effective, because such a large portion of the total weight is utilized as a braking force. The driver brake of a ten wheel engine acts upon only about 75 per cent. of the total weight, and the eight wheel engine, which is the one most used for fast trains, affords the driver brake much the poorest stopping power of all. The eight wheel engine with driver brake only is in precisely the same position as was the twelve wheel car a few years ago, when brakes were applied to only eight wheels; that is, it is supplied with but two-thirds the retarding power that it ought to have. The general reorganization of passenger brake gear, already mentioned, has happily included the application of brake shoes to the middle pair of wheels of six wheel trucks, so that few twelve wheel cars are now running without brakes for all wheels. The prejudice which formerly existed against the use of brakes upon wheels of the engine truck has been exploded, with the result that many of the engines used in fast passenger service are now equipped with brakes upon the leading truck. Just as it is to day generally acknowledged to be a dangerous practice to operate passenger trains without locomotive driver brakes, it may safely be predicted that in a very short time it will be equally well recognized that a reasonable regard for safety requires the use of the engine truck brake. The promptness with which it has been applied to many of the engines of fast trains sufficiently indicates that it is already considered necessary to the safety of that class of passenger traffic.

Concerning the air brake equipment of passenger cars, there appears to be little to add to what has already been said. There is one feature, however, which deserves consideration. The ten inch brake cylinder was adopted for passenger car service at a time when it appeared that a cylinder of that size would meet the requirements of the heaviest eight wheel passenger cars that were likely to be built. The weight of passenger cars has, however, steadily increased beyond those expectations, until it is now in many instances more than 60,000 lb., and in some cases more than 70,000 lb. In order to apply a sufficient braking power to these heavy cars, it has been necessary to increase the brake leverage to such an extent that an excessive increase of piston travel accompanies a small wear of the brake shoes.

While the question of the care of the freight brake is perhaps not properly included within the range of the subject assigned, its relation to the proper application of the brake apparatus and its general importance seem to justify a few words in its behalf. In the past, the chief obstruction to the control of freight trains by the air brake has been the difficulty of securing a sufficient number of air braked cars; one of the difficulties now frequently encountered is the inability to make use of all the air brakes present in trains. It is not infrequently found necessary to cut a portion of the brakes out of service upon freight trains, because it is impossible to maintain the air pressure in all of them. This is in some cases due to the use of small air pumps upon the locomotive; and too much cannot be said of the importance of using air pumps of sufficient size to preserve the proper air pressure and to maintain a liberal margin of excess pressure in the main reservoir without too much labor. The small pumps were designed long ago for use upon comparatively short trains; wherever they have fallen into freight service they are rapidly being replaced by larger ones of sufficient capacity for long trains, and this feature of the trouble will soon be removed. An air pump of large capacity cannot, however, be expected to maintain the proper air pressure in apparatus which is so carelessly applied or maintained that a considerable portion of the air compressed escapes through leaky joints. The constant vibration of cars while in service requires that all air pipes and apparatus should be so firmly secured to the car body that no shaking or rattling of the parts is possible. Where insufficiently seasoned timbers or blocks are used, the shrinkage causes bolts to become loose and the air pipes to rattle. These defects should be promptly and fully remedied, or it will be found impossible to maintain a reasonably tight air apparatus upon such cars. Much more attention is now being given to these matters than formerly and the air brakes are better secured to freight cars, so that it may reasonably be expected that trouble from this source will be proportionally less in the future.

A reasonable perfection in the performance of power brakes seems to depend upon the ultimate selection of a standard metal for brake shoes. It may perhaps be very difficult to select any metal which will be uniform in quality; but it is certain that a much nearer approach to uniformity can be reached in that way than through the use of two or more different metals, or of widely different qualities of the same metal. It would appear to be, first of all, desirable to ascertain which metals produce the most uniform friction throughout

a stop, and what brake shoe pressures must be used with these metals to produce the same amount of friction; this the committee is doing. The wearing qualities of these metals when each is used with its required pressure, coupled with the wearing effect upon the wheel, would then seem to fairly indicate the value of each as a brake shoe metal. There are of course other incidental considerations; for example, it may be found that there is considerable collateral objection to any considerably increased strain upon the brake gear and parts of the trucks, in order to use a brake shoe metal of low friction-producing capacity; also, it may be found that the increase or decrease of the pressure is not accompanied by a corresponding increase or decrease of friction, and the relative increase or decrease may vary with different brake shoe metals.

Following Mr. Parke's paper Mr. E. G. Desoe read one upon the same subject, from which the following abstract is taken:

I think a freight car should be equipped so as to have a brake power of 90 per cent. of its light weight, on account of there being so much difference in the weight of an empty and a loaded car. There are a great many cars in service the light weight of which is 30,000 lb., with capacity of 60,000 lb.; and with braking power 70 per cent. of its light weight, obtainable only with 60 lb. pressure of air in brake cylinder. With 70 lb. train line and auxiliary pressure, to obtain 60 lb. in brake cylinder, the application must be a full emergency, and the piston travel not over 8 in. Assuming we obtain the 60 lb. pressure, we would then have a braking power of only about 23 per cent. of the car's weight when loaded to its full capacity; should a service application be made, with 8 in. piston travel 50 lb. is obtained in the brake cylinder; this would give with the car empty a braking power of about 58 per cent., and when loaded of about 19 per cent. If a partial service application of ten or more pounds reduction has been made when an emergency arises, then 19 per cent. of loaded weight, and 58 per cent. of the light weight, is all the braking power that can be obtained. The reason of this is that after a service application of ten or more pounds reduction has been made, there is no perceptible gain from train line air entering the brake cylinder. This means a loss in braking power from what should be obtained by a full emergency application, on a car weighing 30,000 lb. and braked at 70 per cent., of 3,600 lb. per car, or 180,000 lb. for a 50 car train. Should the brake power be made 90 per cent. of the light weight, then we would have on this same car, with a full emergency application, a braking power of 30 instead of 23 per cent. of its loaded weight, a gain of 7 per cent., which would be about 6,000 lb. per car, or 300,000 lb. on a 50 car train.

As I have already said, I would recommend the placing of hand brake wheels at one end of the car only, and I think the brake power obtained by it should be as high as 70 per cent. of the light weight of the car; also, that it should be the same on both trucks. To obtain the same braking power on both trucks, it is necessary to have the power applied to the cylinder lever at the same point as the air power, for when applied, as it generally is, to the extended end, there is from 1,000 to 3,000 lb. difference in power applied to the trucks. The reason why this is thus is on account of the floating cylinder lever being the same proportion as the cylinder lever without the extended end, which is necessary to obtain the same braking power on both trucks when the air power is used. The loss from this source, with that of the friction, causes the hand brake to be in many cases inefficient.

Some time ago I made some tests to ascertain the loss by friction when the hand brake was used, and found that on a car equipped with a single hand brake there was a loss of nine per cent. between the brake staff and shoes; on a car with a double hand brake, one wheel, a loss of 16 per cent.; and on a car equipped with a double air brake and one hand wheel, connected through rod to extended cylinder lever, a loss of 20 per cent. Thus it will be seen that our hand brakes, as usually arranged on freight cars equipped with air brakes, do not have the same brake power on each truck, as they should, and that there is quite a loss by friction. As some of you may say that with the air brake there is no need of so good a hand brake, I will say that in the short time we have been using the air brake I have known of several cases, on account of air pump out of order, broken train line pipe under tender, or insufficient brake power with the air brakes, that the hand brakes on the air cars were obliged to be used, either in connection with the air or alone, to control the speed on a heavy descending grade. Such cases as these are where we need efficient hand brakes, and those that work with the air, so that a trainman will not hesitate to use them.

HIGH SPEEDS IN THE UNITED STATES.

THE fast train on the New York Central Railway which made a trip of 440 miles at an average speed of 63½ miles per hour, as described in the Engineer of October 4, has been beaten by a train on the Lake Shore and Michigan Southern Railway, which on October 24 made a run of 510 miles in eight hours, or at the average speed of sixty-four miles per hour, including all stops. The figures given below are authentic, having been furnished to our correspondent by one of the principal officers of the company, who was in the train. The train was a special and carried no regular passengers, having been run for the purpose of seeing what could be done with such a fast train, but, like the train on the New York Central Railroad, it had ample carrying capacity for a large number of passengers. It consisted of three cars, weighing in all 304,000 lb., or 136 English tons.

The run was made the whole length of the main line from Chicago, Illinois, to Buffalo, New York. The actual distance between the terminal stations is 540 miles, but the run was only timed for 510 miles—from the One Hundredth Street Station, Chicago, to Buffalo Creek Station, near Buffalo—as all trains have to run slowly near Chicago on account of the work of raising the tracks and the number of junctions and crossings, and near Buffalo on account of the network of freight yards, connecting lines, switches, etc., of the numerous roads entering this city.

There were only four regular stops for changing engines, but an extra stop was made on the Toledo division, the train being signaled to stop on account of some repairs to the track. The highest speed noted for any one mile was 92·3 miles per hour, but the high averages between stops, especially the average of 72·91 miles per hour for the last eighty-six miles, show that very high rates of speed must have been attained at various points on the trip.

	Distance.	Record time. (Morning.)			Elapsed time.		Time consumed in actual stops.		Speed. Miles per hour.
	Miles.	h.	m.	s.	m.	s.	m.	s.	
Left 100th Street, Chicago, Ill.	..	3	29	27	....				
Arrived Elkhart, Ind.	87·4	4	54	53	85	26			61·38
Left Elkhart, Ind.	..	4	57	04	....		2	11	
Arrived Toledo, O.	133·4	7	01	39	124	35			64·24
Left Toledo, O.	..	7	04	07	....		2	28	..
Stop by signal at Port Clinton	..						2	05	..
Arrived at Cleveland, O.	107·8	8	50	13	106	06	..		60·96
Left Cleveland, O.	..	8	51	58	....		1	45	
Arrived Erie, Pa.	95·5	10	17	30	85	32	..		66·99
Left Erie, Pa.	..	10	19	48	....		2	18	..
Arrived Buffalo Creek, N. Y.	86·0	11	30	34	70	46	..		72·91
Total running time (deducting stops)	510·1		......		470	20	10	47	65·07
Total time of trip, including 10 minutes 47 seconds of actual stops, and also including 24 times slackening speed for railway crossings, and 14 other times slackening speed	510 1		......		481	07	..		63·61

This record shows an average speed from start to finish, including all stopping and slackening speed, of 63·61 miles per hour for 510 miles.

As already noted, the train consisted of three cars; two were Wagner drawing room cars, weighing 92,500 lb., or 41·3 English tons each, and the third was a private car weighing 119,500 lb., or 52 tons; the total weight behind the tender being 304,500 lb., or 136 tons. Each car was mounted on two six wheeled trucks or bogies, and would carry forty to fifty passengers. (The fast train on the New York Central Railroad had a seating capacity for 218 passengers.) Four engines were used. Those on the first three divisions of the trip were of the eight wheel type, having four coupled driving wheels and a four wheel leading truck or bogie, while on the last division an engine of the ten wheel type was used, having six coupled wheels and a four wheel leading truck. It was this latter engine which gave the highest record. The total weight of the train, including engine and tender, was 488,500 lb., or 211 English tons, with the eight wheel engines, and 502,500 lb., or 225 English tons, with the ten wheel engine. The tenders were all alike, carried on two four wheel trucks.

The New York Central Railroad and the Lake Shore and Michigan Southern Railroad form one of the principal routes between New York and Chicago. The former has now a record of 440 miles in seven hours, and the latter 510 miles in eight hours. It is now suggested that a record of fifteen and a half hours might be made for the entire distance of 980 miles, or at the rate of about 63 miles per hour, but, of course, there is no likelihood of, or little reason for, a regular train of this kind. During the summer of 1893 this trip was made twice daily in twenty hours, or at an average speed of 49 miles per hour, the traffic to the Chicago Exhibition having been so enormous as to make this a paying investment, the train being a popular one in spite of the extra fare charged upon it. That train, known as the "Exposition Flyer," was undoubtedly the fastest long distance express train ever run.

The information is supplied by our own United States correspondent, and he assures us that the figures are official, and consequently substantially accurate. We have always looked with doubt on the high speed statements which have come to us from the other side of the Atlantic, because we know that the chances of making a mistake in taking time augment very rapidly with the speed. In the present case, however, there is no room left for doubt on this score; either the figures have been deliberately falsified, or a stupid blunder has been made; or a train has actually run for not half a mile or so but for a great many miles at a speed of nearly seventy-three miles an hour. This we are quite willing to admit beats all previous records. It is the most remarkable piece of locomotion the world has seen. It is so far a unique performance. Let us see what it really means. What effort it involved. How far it complies with fixed conditions. What it has to teach us.

We may note at the outset that the work has been done by a very ordinary locomotive. Hitherto we have always associated excessive speeds with very large and heavy engines. In this case four different locomotives were used, but we may confine our attention to the last. It has six coupled drivers 5 ft. 8 in. in diameter, 17 in. cylinders, 24 in. stroke—nothing in any way abnormal; indeed, as things go, rather a small engine for express work. The total weight moved was 225 tons or thereabouts. Now, seventy-three miles an hour is 6,424 ft. per minute, or 107 ft. per second—we omit fractions, because they are of no account in these calculations. The performance was far too remarkable to depend for its interest on fractions of a foot, or a minute, or a revolution. A 5 ft. 8 in. wheel makes 297 revolutions per mile, and at 73 miles an hour about 359 per minute. Therefore a 24 in. stroke gives 1,436 ft. of piston speed per minute, and for two 17 in. pistons 30 horse power nearly for every 1 lb. of effective pressure in the cylinders.

Now, considering the extreme difficulty incurred in getting the steam out of the cylinders at these excessive speeds, above all in an outside cylinder engine; and the wire drawing which must have taken place in getting the steam into the cylinder, we do not think it is possible that the average effective cylinder pressure could have exceeded 50 lb. on the square inch. And in saying this we fancy we shall have all who have had much to do with indicating locomotives at exceptional speeds on our side. This pressure represents then, say, 1,500 horse power indicated as the maximum power of the engine. While the very high piston speed, on the one hand, represents augmented power, the difficulty of getting the steam into and out of the cylinder involves at least a corresponding loss of effective pressure. It is a well recognized fact that the power of express locomotives varies very little with speed. Thus, at sixty miles an hour and eighty miles an hour, the power would probably be the same, the higher average effective pressure in the former case compensating for the lower piston speed. We may here ask if it was possible that 1,500 horse power could be got out of a boiler with 1,700 square feet of heating surface. We answer emphatically, no, it could not, at least for any considerable period. To keep it up for an hour and twenty minutes would be out of the question. The effective pressure, therefore, must have been much less than 50 lb., probably nearer the half of it. Judging by the records of very similar engines which have made long runs, we think we shall not be far off the mark if we assume that the engine developed 700 horse power, which would have been a very fine performance even with so large a boiler. Let us see what was done with the power.

At seventy-three miles an hour 5·13 lb. represents a horse power nearly. The available tractive effort, then, was $5·13 \times 700 = 3,591$ lb., or a little over 15 lb. per ton. Can we bring ourselves to believe that a train composed of very bulky cars can have been run at seventy-three miles an hour with a tractive effort of about 15 lb.? Nothing over is left for engine friction, and the engine was six coupled. But experiments made with much care in the States have shown that not more than about one-half the horse power of a locomotive is available for hauling the train. If such a statement holds good in the present case, then the tractive effort needed must have been less than 14 lb. or so per ton of car.

Assuming that the statements made officially to our representative are correct, inasmuch as it is evident that the train could not have been running continuously down hill for eighty-six miles, it is impossible to avoid the conclusion that train resistance absolutely becomes smaller as the speed augments when once a certain velocity has been attained, leaving out the effect of curves and inclines. It is known that the rolling friction, that is, in other words, the resistance to the rolling of the wheels on the rails, is very trifling, and nearly constant at all speeds. Then comes axle friction. The result of Wood's experiments in the early railway days have never been controverted. They showed that the rolling resistance may be taken as the 0·001 part of the weight, that is to say, in a train weighing 225 tons, the resistance would amount to about 500 lb. only, and this is a uniformly retarding force at all speeds. Of course, to overcome it at the rate of ninety miles an hour requires the expenditure of twice as much force as is needed to deal with it at forty-five miles an hour. But, at all events, the dead pull against the engine does not augment with the speed on this count. As to axle friction, there have been no direct experiments of any importance made recently.

Mr. Towers' experiments have a bearing, no doubt, on railway axle friction, but they in no way cover the ground or give us an accurate idea of what railway friction is, or the laws which it follows. Wood's experiments have not received the attention they deserve, and they ought to be brought before the world once more. His conclusions were, that in practice we may consider the friction of carriages moved along railways as a uniform and constantly retarding force; that there is a certain area of axle-bearing surface combined with insistent weight when the resistance is a minimum, and that when the area of bearing surface is apportioned to the insistent weight, the friction is in strict ratio to the weight. Assuming these conclusions to be sound, it will be seen that the tractive effort or pull is a constant at all speeds, and that the horse power needed to exert it varies precisely with the speed. If this be doubled, so will be the horse power, and so on. The resistance of curves and inclines must be constant, and the power exerted will vary as the speed only. The main element remaining then for consideration is the resistance of the air, about which, unfortunately, less than nothing is known if we reject Lardner's celebrated experiments, which showed that it depended solely on the bulk of a train for its amount. But, in any case, no one knows what that amount is.

There are further losses due to oscillations: the striking of flanges right and left; the sinking of permanent way, and so on; all these represent loss, and have been made the subject of careful inquiry in France. If we take the figures obtained by M. Dieudonne, for example, the American performance was impossible. Everything, however, tends to prove that the resistance of railway trains at high speeds has been very much exaggerated. But granting this, it seems to be clear that the resistance of trains in the United States must be less than in this country. We do not believe that any six coupled English engine with 17 in. by 24 in. cylinders and 5 ft. 8 in. wheels could haul an English train, weighing with engine and tender 225 tons, at seventy-three miles an hour, for eighty-six miles on a level. It is not for us to say that official figures lie; but it is open to us to say that if the speed said to have been attained on the line on the day named was really attained, then it is certain that there is some peculiarity about American track and American rolling stock that is not found elsewhere in the world; and we advise all railway men in the country to hasten to ascertain what it is. Ostensibly the performance was almost impossible on a level or compensating track. We shall not, we think, be considered rudely incredulous if we ask for further explanations.—The Engineer, London.

ROY STONE'S REPORT TO SECRETARY MORTON ON AMERICAN ROADS.

ROY STONE, special agent of the Agricultural Department, has made the following report to Secretary Morton on the condition of the roads of the United States.

The office of road inquiry of the Department of Agriculture has completed an interesting investigation relating to the uses of the common roads in the United States, the results of which will be published as Agricultural Circular No. 19. With the aid of the division of the statistics of the department, reports have been gathered from about 1,200 counties, giving the average length of haul in miles, from farms to market or shipping points, the average weight of load hauled, and

the average cost per ton per mile, and from this is deduced the average cost per ton for the whole length of haul. These returns have been arranged in groups of States, and the results show that the

AVERAGE LENGTH OF HAUL

in the Eastern States is 5·9 miles; in the Northern States, 6·9 miles; in the Middle States, 8 8 miles; in the cotton States, 12·6 miles; in the prairie States, 8·8 miles; in the Pacific Coast and mountain States, 23·3 miles; and in the United States, 12·1 miles.

The average weight of load for two horses in the Eastern States is 2,216 pounds; Northern States, 2,136 pounds; Middle-Southern States, 1,869 pounds; cotton States, 1,397 pounds; prairie States, 2,409 pounds; Pacific Coast and mountain States, 2,197 pounds; and the United States, 2,002 pounds. The average cost per ton of 2,000 pounds per mile in the Eastern States is 32 cents; Northern States, 27 cents; Middle-Southern States, 31 cents; cotton States, 25 cents; prairie States, 22 cents; Pacific Coast and mountain States, 22 cents; and the United States, 25 cents. The average total cost per ton for the whole length of haul: Eastern States, $1.89; Northern States, $1.86; Middle-Southern States, $2.72; cotton States, $3.05; prairie States, $1.94; Pacific Coast and mountain States, $5 12; and the United States, $3.02.

With these data it becomes possible to obtain approximately the total cost of the entire movement of farm products and other classes of materials over country roads. Taking the census returns of the farm products of the United States for 1890, adding eight per cent. for the increase in five years corresponding to the increase in the previous ten years, finding the weights of the various articles and reducing the total to tons of 2,000 pounds, we have a

TOTAL WEIGHT

of farm products for the year 1895 of 219,824,227 tons. Taking the amounts by States, Iowa leads with 24,287,000 tons; Illinois comes next with 21,000,000 tons; Kansas with 17,000,000; Missouri, New York, Ohio and Nebraska with 12,000,000 to 13,000,000 tons; Indiana and Pennsylvania, about 10,000,000 tons; Michigan, Minnesota and Wisconsin, 7,000,000 to 8,000,000 tons; Texas, Colorado, Kentucky and Tennessee, 4,000,000 to 5,000,000 tons.

No information is available as to the amount of hay and grain consumed upon the farms where they are raised, nor is there any return of large classes of materials moved over the country roads, among which are building materials, including stone, lumber, brick, lime and sand; fencing materials; road materials, gravel, stone, etc.; fertilizers, commercial and domestic; lime and plaster, coal, ore and metals, straw and fodder, home killed meats and animals driven to market, garden products and grass seeds, poultry and eggs, merchandise, farm machinery.

It is deemed safe to offset these various items against home consumed hay and grain, and to count the total farm product as hauled on the public roads. The division of forestry of the department furnishes an estimate of forest products as follows: Annual cut of fuel, 18,005,000,000 cubic feet; mill product, 5,000,000,000 cubic feet. Total, 23,000,000,000 cubic feet.

The chief of the forestry makes the very safe estimate that one-fourth of this total, or 5,750,000,000, is hauled over the public roads. Adding timber used for railroad construction, 485,000,000 cubic feet, makes a total of 6,235,000,000, which is 30 pounds per cubic foot, gives 93,525,000 tons of 2,000 pounds. Adding this to the total farm product gives 313,349,227 tons, which at the average cost above stated, $3.02 per ton, makes a grand total for the annual cost of haulage on the public roads of $946,414,665.54. The immensity of this charge will be best realized by comparing it with the values of all farm products in the United States for the year 1890—$2,460,170,454.

What portion of the total cost of haulage is chargeable to bad roads can be better ascertained when the report from our consuls abroad regarding the cost of haulage on good roads is received. This information has been asked for from the State Department by the Secretary of Agriculture in a recent communication. The actual

INCREASE IN COST OF HAULAGE

done is by no means the only loss by bad roads. The loss of perishable products for want of access to market; the failure to reach market when prices are good, and the failure to cultivate products that would be marketable if markets were accessible all the year round, add many millions to the actual tax of bad roads. Moreover, the enforced idleness of millions of men and animals during large portions of the year is a loss not always taken into account in estimating the cost of work actually done.

Information already in possession of the office of road inquiry indicates that, all things being considered, nearly if not quite two-thirds of this vast expense may be saved by road improvement, and at a cost not exceeding the losses of three, or at the most four years, by bad roads. There is at least enough in these facts to justify the assertion of the National League for Good Roads, indorsed by the Chamber of Commerce of the State of New York, that "The movement for good roads deeply concerns every commercial and financial interest in the land. We are handicapped in all the markets of the world by an enormous waste of labor in the primary transportation of our products and manufactures, while our home markets are restricted by difficulties in rural distribution which not infrequently clogs all the channels of transportation, trade and finance."

THE PERCEPTION OF LIGHT.*

By Sir G. G. STOKES, F.R.S.

AT a former anniversary I brought before the members of the institute the subject of the luminiferous ether. It is one of great and growing interest. I mentioned on that occasion how discoveries of very recent date have led us to attribute continually increasing importance, and a widening range of function, to that medium—substance can I call it?—the existence of which was originally assumed as a hypothesis in order to account for the phenomena of light. It is in connection with this last aspect that it relates to what I propose to bring before you to-day.

The wonderful sense of sight, which, to use an expression of Sir John Herschel's, confers upon us to some extent the character of ubiquity, requires two things: in the first place, some means by which those distant bodies which we see are able to affect our own neighborhood; in the second place, some provision in our own bodies for receiving that influence, and transmitting some sensation to the conscious being.

In my former address I considered the first of these two subjects; to day I mean to confine myself to the second. This second, even by itself, is, however, far too wide for a single address; selection of some kind is imperatively demanded. Moreover, there are some parts which are accurately known, and may even be made the object of mathematical calculation, while there are others which not merely lie beyond our existing knowledge, but beyond any that we can hope to attain to, at least in this life. Wonderful as is the construction of the eye in all its parts, so far as relates to the formation of images on the retina, it acts simply like an optical instrument, like a telescope or microscope, or, more correctly, like the objective of such an instrument, and we may apply our mathematics to tracing the course of the rays through it. On the other hand, even if we knew accurately—which we do not—the nature of the effect which the external agent produces on the ultimate structure of our bodies, there would still remain, shrouded in impenetrable mystery, the nature of the process by which some change in the bodily organism causes a sensation to the conscious being.

Between these two extremes lies a region which has been to some extent explored, and in which a gradual and perhaps at last a very substantial increase to our existing scientific knowledge may be looked upon as probable. The investigation of this region possesses the keen interest which belongs to the discovery of new truths, and the addition thereby made to the stock of human knowledge. It is to this borderland lying between the well known and the unknown, and to certain parts of the structure of the eye having relation to it, that I would for a short time direct your attention to-day.

As I have already intimated, I propose to pass by entirely the functions of the eye acting as a simple optical instrument in forming images on the retina. The explanation of that may be found in all the ordinary text books, and I will not weary you by repeating what is there to be found, and which is generally familiarly known.

The phenomena of vision show that distinctness of vision is dependent somehow or other in the first instance on the formation of distinct images of external objects on the retina. In that formation, as I have said, the transparent portion of the eye, the cornea, the aqueous humor, the crystalline lens and vitreous humor, plays the part of a lens in an optical instrument. I have said the "formation of the images on the retina;" but the retina is not a mere surface, it has a certain amount of thickness, although it is, on the whole, very thin. We may further inquire on what part of the retina, considered at different depths from the place where it first commences, on which of the various layers into which histologists have divided it, is it that we have reason to think that light first acts on the organism of our bodies in such a manner as ultimately to give us the sensation of vision?

I have said that the retina, as a whole, though very thin, is not a mere surface. If we go from the center of the eyeball outward, i. e., toward the back of the body, we have first a plexus of very fine nerve fibers which run along the front of the retina, and ultimately unite in the optic nerve, which runs into the brain. We have also minute blood vessels, which are essential, apparently, for the growth from its original state, and for the nutrition of the eyeball, and for the carrying on of the process for which it was designed, viz., that of enabling us to see. Then we have several layers of pulpy transparent substances which have been called ganglions, nuclei, and molecules, mixed with very fine fibers. Some of these are nerve fibers, others are believed by anatomists to have relation to the fixing of the various parts of the structure to one another, so that they shall not fall to pieces in the rapid motions of the person using the eye.

Outside all, at the back surface of the retina, there is what is called the choroid coat; but between that and the coats I have spoken of is a very remarkable structure which I shall have to say more about. It is called the bacillary layer. In this part of the retina we have a vast number of elongated bodies placed closely, side by side. In the human eye, and in the eyes of most animals, they are of two shapes, and have been called accordingly rods and cones. The rods, as the name implies, are cylindrical, and the cones are tapering and are somewhat of the shape of slender peg tops, the sharp side being turned inward as regards the way you look, so that the light, in coming from the outside, first meets the bases of the peg tops, and then goes on toward the point. About the point of these rods and cones, just close to the choroid coat, is a layer of pigment cells which absorb the greater part of the light falling upon them. The rods and cones are transparent, and allow the light to pass through them, passing lengthways. I said the extremities reached to the layer of pigment cells, forming a black lining immediately inside the choroid coat. That is true of the rods, but the cones do not reach quite so far, i. e., when the eye is in a state of repose, as in darkness; but under the stimulus of light these pigment cells come down, i. e., forward, in the direction in which you look, so as to reach the tops of the cones as well as of the rods. I have said that these elements (remember, please, that they point radially in the direction in which you are looking, and lie side by side) are exceedingly numerous. When they are looked on lengthways from the back of the eye when the pigment is removed, they form a sort of mosaic. You may imagine the general structure of them by thinking of the head of the common sunflower in seed. They are arranged side by side, something like the seeds of the sunflower; but they lie so close that the distance between the neighboring rods or cones, as the case may be, is only about (it varies somewhat from one part of the eye to another) $\frac{4}{1000}$ part of a millimeter, or say about $\frac{1}{6000}$ part of an inch. So numerous are they that a square with sides the tenth of an inch would cover nearly half a million of them.

Now something more about these rods and cones. They are found to be composed of two members or limbs, an inner (nearer the center of the eyeball) and an outer. The inner is a transparent looking body, very much like the other bodies in the neighborhood. The outer is transparent too; but it is found to be highly refractive. It is longer in the rods than in the cones. The outer segment of the cones may be represented to the mind's eye by thinking of the metallic point of a peg top. These outer limbs are in both cases readily detached (when the eye is dissected) from the inner, and they separate after a little into laminæ, lying one on the top of the other, perpendicular to the axis of the rod or cone. At the outer end they do not appear to have any continuation, the structure stops. At the inner end (corresponding in the case of the cones with the bulbs of the peg tops) there come nerve fibers from each of them. These pass through the various layers that I have spoken of; and although the course of them has not actually been traced the whole way, on account of the difficulty of examination of this pulpy structure, it is pretty certain that they join on to those nerve fibers which line the front surface of the retina, and so pass on, through the optic nerve, to the brain. When I say "pass on" I mean of course as you trace them along; there is no motion in the case. This is a very remarkable structure. Has it any object? What is its object? Now we know by experience that if we have a single point of light exposed to us, the impression is that of a single point of light in the field of view. If there be two such points we have the impression of two luminous points, occupying different positions in the field of view. Now two such points may be very close to one another, and yet we still see them as two. It is found that the limit of closeness, beyond which we are unable to distinguish two objects as two, is such that a line drawn between them subtends at the eye an angle of about one minute or an angle of about $\frac{1}{30}$ part of that subtended by the diameter of the moon. Yet although they exist as close as that, the impression of the two is distinct, and we might have a number of points, each giving a distinct impression. It appears, therefore, that for the purpose of vision it is necessary that stimulations coming from a vast number of independent points, having different bearings from the eye, should, somehow or other, give rise to distinct impressions.

Now, if by calculation we trace inward, to the retina, the course of the axes of two pencils coming respectively from two distant points not far from the center of the field, it is found that those axes intersect, not exactly in the center of the eyeball, but in a point (called the optical center) a little in front of it, the position of which we can calculate; and the place of either image may be found by joining the external point with the optical center, and producing the joining line to meet the retina. It is an easy matter now to calculate the distance on the retina of the images of two external points which subtend at the eye a known angle; and it is found that when the external points are so close as only just to be seen as two, the distance of the two images is about the $\frac{4}{1000}$ of a millimeter, just about the distance apart of the cones and rods from one another, lying so closely as I have explained they do. Here, then, it would appear, in this remarkable layer of the retina, we have a provision enabling us to have distinct sensation of a vast number of distinct points in the field of view; and consequently we have reason to suppose that the effect of light, whatever it be, on one of these elements (be it cone or be it rod) gives rise to the sensation of a point; and that the position of that point in the field of view depends upon the position of the element of the bacillary layer which has been affected by the light coming from the point. Moreover, in the nerve fibers which come from the anterior ends of the rods and cones we appear to have a provision for communicating, through the optic nerve, to the brain, the influence, or an indication of the influence, which light exerts on one of these elements.

Now I have mentioned one argument for believing that this remarkable bacillary layer is that in which light, which previously merely passed through the eye as it would through an optical instrument, acts in some manner on the organism so as to give rise to stimulation of the nerves which convey to us the sensation of vision. The argument so far is a sort of à priori one, but it has been remarkably confirmed by an experiment of H. Müller's, made by means of Purkinje's figures.

When in a room which is not quite dark we look with one eye, toward a moderately illuminated wall with uniform surface, and holding a candle to one side of the eye, move it up and down, there is seen in the field of view a figure branching like seaweed. This is the shadow of the blood vessels of the retina. That the candle requires to be moved in order to show the figure is explained by the consideration that the shadow is not black, but only darker than its neighborhood, and when the light is steady the exhaustion of the eye for that part of the field which lies beside the shadow tends to equalize the apparent illumination of the parts in and out of shadow; whereas when the candle is moved the shadow falls on a new place which had been in full light and therefore partially exhausted, and the previous exhaustion and the new partial interception of light falling on that place contribute to make the shadow sensible.

The existence of a shadow shows already that the percipient layer of the retina must lie behind the blood vessels. But we may go a step further. By suitable methods of illumination we may cause two spots on the surface of the eyeball, whose positions can be determined from the circumstances of the experiment, to be alternately virtually the sources of the light which casts the shadow, and the places in the field of view of the shadows of the same vessel in the two positions of the illuminating source can be marked. It is then only a question of similar triangles to determine how far behind the blood vessels lies the percipient layer, and the distance thus calculated is found to agree, within the limits of errors of observation, with the distance of the bacillary layer as determined by microscopic examination of a dissected eye.

I have said as you go backward from the center of the eyeball, you have, in front of the rest of the retina,

* Presidential address delivered at the Victoria Institute by Sir G. G. Stokes, F.R.S.—Nature.

a plexus, as it is called, of nerve fibers lying side by side, something like the threads in a skein of silk, but gradually leading onward to the optic nerve. Light passes across these, but it does not excite the nerves in passing through them. The nerves are transparent, and the light produces no effect upon them directly. If it did, your whole field of view would be confused, because it is known that when a nerve is excited the sensation is referred to a particular part, no matter where the nerve may be affected. Suppose you could isolate, say in the thigh, a particular nerve leading to the great toe, and pinch it without hurting its neighbors, you would feel the pinch not where the nerve is pinched, but in the great toe. So, here, if these nerve fibers were excited by the passage of light through them, then the sensation corresponding to the excitement of a particular nerve fiber, which would be that of a definite point in the field of view, would be excited by an external luminous point lying anywhere in the curve in which the surface generated by a straight line passing through the optical center and intersecting the fiber in question would cut what we may call the celestial sphere, and the correspondence between the subjective points in the field of view and objective external points would be lost. And the fact that the visual nerves are not affected by light which passes across them is further shown by the well known experiment of the blind spot, where the optic axis passes out of the eyeball, not in the axis of vision but to one side, toward the nose, so that an object whose image falls on the blind spot of one eye is seen by means of the other.

But now comes a question, and here we enter on uncertain and debated ground—How is it that the nerves are stimulated by the light at all?

We have reason to believe that these rods and cones form the means by which the light, acting on them, causes the stimulation of the nerve. As I have said, they consist of two elements, an inner and outer; the outer from the center of the eye, i. e., the inner as regards the body, being of that remarkable structure which I have described. It has been questioned which of these two elements it is that you are to regard as the percipient organ. I do not know that physiologists have decided that question. I have looked into a paper of Max Schultze's—in fact I have it on the table—and he inclines to the opinion that it is the outer element. Now is there anything in the outer element which can conceivably form a means of stimulation of the nerve, when that element is acted upon by light?

I have spoken of the way in which it is composed of laminæ which come to pieces when dissected, after a certain amount of maceration. I do not know whether it may not be rash to say what I am about to say, because I do not know that physiologists have suggested it—it is merely an idea which occurred to myself, so you must take it for what it is worth. I was reading an account of the electric organ of electrical fishes, such as the torpedo. It is a very remarkable organ, occupying a considerable space in these fishes. It has a columnar structure, and the column again consists of laminæ placed one over the other. It has a structure which may roughly be compared to that of the basaltic columns in the Giant's Causeway, only here you must think of laminæ as more numerous and not having that curved surface shown in the Giant's Causeway. Now nobody questions that somehow or other this is an organ by means of which these fishes are enabled to give a shock, and the idea, of course, is suggested, are not these laminæ like the plates of a battery? Is not one of these columns, roughly speaking, something like a galvanic battery? But how the battery is charged and discharged we do not know. In this case it depends, no doubt, on the will of the animal as to what it does, and nobody knows how he brings that about.

Now it strikes me that there is a remarkable apparent analogy between the outer member of the rods and cones and these columns in electrical fishes. This gives rise to the suspicion that possibly these outer members may act the part of a microscopic battery, being charged somehow or other. But how are they to be charged? Well, before I go on to enter into any speculation on that I may mention that some years ago Professor Dewar and Mr. McKendrick made some remarkable experiments, the results of which are given in a paper published in the Transactions of the Royal Society of Edinburgh. When an eye is dissected out, and the cornea is connected through a wire with non-polarizing electrodes to the middle of the section of the optic nerve, the wire being led through a delicate galvanometer, it is found that there is a certain amount of electric current passing. Now it was found that when the eye (having been in darkness) was allowed to have light shining upon it, there was a change in this current, and a change again when the light was cut off. It is true that the total change was only a small fraction of the whole; but still that there should be any change at all produced by the action of light is a remarkable thing. It looks very much as if the stimulation of the nerve had something or other to do with the production of electric currents; but those, if they are produced, we must suppose to be produced in some way by the action of light. How may we imagine light to act so as to produce them? It has been discovered that in the layer of pigment cells in the retina there is a substance, called visual purple, of a purple color, which is acted on by light, and is made first yellow and then nearly colorless. We have thus a substance that is capable of being acted upon by light, as very many substances are. I do not say that it is by any means proved that that is the substance, or even that there is any substance, which is acted upon by light in the way demanded; yet it seems very probable that the change produced by the action of light, whether it be on visual purple, or some other substance associated with it, may give rise to something which may, so to speak, charge this microscopic battery and stimulate the nerve fiber which is attached to it.

We know the rate of the vibrations of light of various kinds; and the rapidity of vibrations is so enormous, ranging about four hundred millions of millions of vibrations in a second, that we can hardly imagine that the organism of our bodies is calculated to be set in vibration in a corresponding period. In that respect the sense of sight differs notably from the sense of hearing. In hearing the tympanum of the ear is thrown into vibration, and the vibrations are not so enormous in number in such a time as one second but that the corresponding nerves may actually be mechanically agitated, and thereby in some way stimulated. We can hardly imagine that the visual nerves are acted upon in this sort of way directly by the luminous vibrations, but they may be indirectly. Here, again, I may throw out a possible conjecture, though I am less disposed to receive it myself than that which I have just mentioned. We know there are substances which when acted upon by light continue to shine in the dark. In some cases the action ceases almost instantly after the exciting light is cut off; for instance a solution of the salts of quinine, where the rapidity of cessation of the effect is amply sufficient to tally with the rapidity of cessation of visual sensation when light is cut off.

There are various other matters connected with the perception of light which are of great importance to our well-being and to our enjoyment which I have not ventured to touch upon at all. It would take a great deal too long to go into two which I will only just mention. One is the provision in the two eyes, and in the muscles which move them, which enables us to obtain single vision notwithstanding that the two eyes are at work. Nothing is easier than to obtain double vision in which the images seen by means of two eyes occupy different positions in the field of view. There are very remarkable contrivances for bringing about singleness of vision in the habitual use of both eyes.

Then, again, we do not see light merely as light, but we see a great variety of color. We can distinguish one light from another light by its color, and not by its intensity only. It would take me a great deal too long to give you any idea of what is known (which after all is not much) as to the way in which that is effected.

[Continued from SUPPLEMENT, No. 1044, page 16688.]

NOTES ON GOLD MILLING IN CALIFORNIA.*

By ED. B. PRESTON.

ASSAYING AND SAMPLING.

ALTHOUGH at present most California mills have their own assayers to test the ore and the tailings, the time was not so very remote when it was not considered requisite to do any assaying. The expert millman could tell (?) by horn-spoon test how much his ore would mill to the ton; and if a horn-spoon test of the tailings showed no amalgam, he confidently asserted that all was being saved. It was decidedly a case where "ignorance was bliss." No gold milling can be carried on understandingly without light being thrown on the different results achieved, and which can only be given by careful sampling and assaying. It is not sufficient to know that a certain loss has been sustained. It should be accompanied by a knowledge in what particular part of the operation the loss has been incurred, to enable the operator to remedy the evil; hence, the necessity of constant sampling and assaying. In some cases the loss will be found entirely in the coarse sands, indicating that the screens are not fine enough; again, the loss may be entirely through sliming of the ore, or the missing percentages of gold will be found mostly in the sulphurets. The assay test alone, with correct sampling, furnishes the knowledge.

Sampling.—Samples should be taken regularly of the ore as it comes to the mill, as well as of the tailings as they pass off, for without the knowledge derived from these two operations there is no means of controlling the work.

Ore, as it arrives at the mill, is sampled by taking a stated amount (shovelful) from each ore car or wagon, and throwing the samples together in a pile on a clean swept floor or into a small bin. The pile should be shoveled over after breaking the pieces to the size of macadam; or if the pile be too large, cut through it at right angles, throwing the rock from the trench thus made in a pile by itself. This should be crushed or broken to a nearly uniform size, mixed by shoveling, and made into a low, truncated cone, which is divided into four equal parts by making a cross on the surface, and throwing out two diagonal quarters, which are again reduced in size, made into a second similar cone, and treated as before. This quartering and crushing is continued until a half-pound sample is obtained for fire assay. Great care must be observed when removing the different quarters to see that all the fine dust is swept up and added to the pile each time, as otherwise very defective results will be obtained. The rest of the ore is returned to the main ore bin. Samples taken in this way from the aprons of the self-feeders are likely to give a more correct average, having been crushed, and the coarse and fine duly mixed. Samples should be taken at regular intervals from the pulp with the water that has passed over all the plates, and also from the concentrators.

Tailings samples should be taken at stated intervals by passing a vessel across the entire width of the discharge, where they leave the mill, without permitting any to flow over, and gathering at each interval an even amount. This is allowed to settle in a bucket and the clear water then poured off carefully or drawn off with a siphon. The residue is dried and thoroughly mixed, and several packages of 5,000 to 10,000 grains each weighed out. In some mills tailings samples are obtained automatically, using their current as the motive power for the sampler, which works by intermittingly deflecting a spout through the tailings where they finally drop from the sluices, obtaining the sample across the entire section of the current. An appliance for this purpose is shown in the accompanying drawing. (Fig. 36.)

To ascertain the amount of slimes in the tailings sample, put one of the packages into a bucket, add water, and stir it. After settling two or three minutes, pour off the muddy water into a separate vessel; repeat this operation until the water comes off clear; add a little powdered alum in the vessel containing the muddy water, and when the mud has all settled, draw off the top water carefully and evaporate the remainder. Dry the washed sands of the sample, and pass through different sized screens, weighing the different amounts as they have passed, and assay each size; this will show where the greatest loss is sustained.

To ascertain where the loss in sulphurets occurs, it is sufficient to pass one of the 10,000 grains samples through a 60 mesh wire screen; weigh that which passes through and that which remains on the screen, and pan out each lot carefully by itself, from one pan into another, as long as sulphurets can be recovered; then weigh each batch of sulphurets separately.

The use of 10,000 grains is recommended, as every 100 grains is 1 per cent. and each grain is $\frac{1}{100}$ of 1 per cent.; it is also a convenient size for obtaining accurate results. By using pulp samples instead of tailings, the amount of sulphurets in the ore may be ascertained.

If the sulphurets assay \$75 per ton, and the quantity per ton is 1·7 per cent., the value of the sulphurets in one ton of ore is found by multiplying \$75 by 0·017, which would be \$1 27 per ton. If the loss of sulphurets in the tailings is 11 grains out of the 10,000 grains sample, and the value of the sulphurets is \$75 per ton, then multiply \$75 by 0 0011, and the value of sulphurets in the tailings is found to be \$0·0825 (8¼ cents) per ton of tailings.

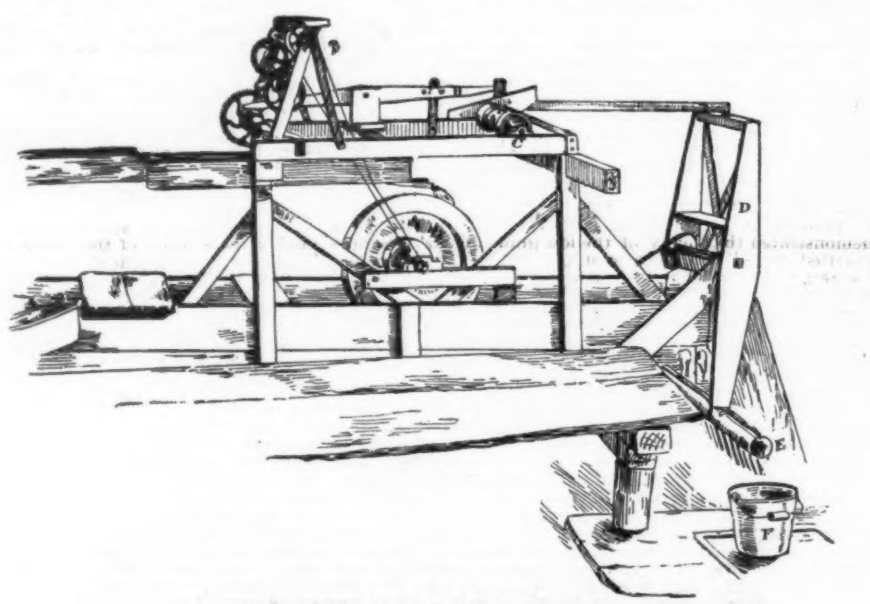


FIG. 36. EMPIRE AUTOMATIC TAILINGS SAMPLER.
Overshot water wheel actuates wheels B, which at stated intervals operates frame D, the tailings sample passing through E, into the bucket or receptacle F.

MILL ASSAYS.

Amalgamation (Free Gold) Assay.—Take two pounds (being exactly one thousandth part of a ton) of ore, crush in an iron mortar, and pass through a No. 60 sieve; remove the gold and other metallic substances left on the sieve, and place in a small porcelain dish containing a little dilute nitric acid, to remove any adhering crusts of oxide of iron, etc., which might prevent amalgamation; these residues are then carefully washed and thrown into the sifted ore, which is then placed in a Wedgwood ware mortar and mixed with enough warm water to make a stiff paste. To an ounce troy (480 grains) of new, clean mercury, free from gold, add a piece of clean sodium about the size of a pea. The mercury thus highly charged with sodium is then thrown into the mortar containing the sample, and the mass ground constantly for an hour, when amalgamation should be quite complete. The mass is then transferred to a gold pan and carefully washed over another pan or tub, in which the tailings are caught, and rewashed to save anything which may have escaped. The mercury is collected and transferred to a small dish; if it be much floured and refuse to run into globules, stir it with a small piece of sodium held in the end of a glass tube, which will cause it to run together. The mercury is then washed carefully in clear water and dried with blotting paper. It is then reweighed, and if the loss exceeds 5 per cent. the

* From Bulletin No. 6 of the California State Mining Bureau. J. J Crawford, State Mineralogist.

assay must be rejected and a new one made. The mercury is next transferred to a small annealing cup or crucible, which has been carefully black leaded inside, covered with a porcelain or clay cover, and volatilized with a gentle heat. When all the mercury has been volatilized, about 50 grains of assay lead are thrown into the crucible and melted, giving it a rotary motion while in a molten state. It is then removed, cupeled, and the "button" weighed. It may be assumed without sensible error that the mercury lost in the operation carried the same proportion of gold as is contained in the mercury recovered; hence the gold contents of the ore will be found by multiplying the weight of the "button" obtained by the weight of the original quantity of mercury, and dividing the product by the difference between the weight of the mercury recovered and the "button." This figure, multiplied by 1,000, gives the weight, in grains, of the free gold and silver per ton of ore, which, for all practical purposes, may be assumed to be all gold. Should, however, greater accuracy be desired, hammer the "button" flat and thin, and dissolve the silver from it with nitric acid, and weigh the gold. The difference in weight represents the silver.

Panning Assay.—Take two lb. of ore, crush, and pass through a No. 40 sieve; any gold in the residue left on the sieve being set aside. The sample is then carefully panned, and the tailings repanned, to make sure nothing is lost. This operation will show at once whether the ore is rich in sulphates or not, and the nature of them. The visible gold should be panned as free as possible from all the sulphurets, taking care that none is lost. The pan and its contents, together with the residue left on the sieve, are dried by holding over a fire; the contents are brushed into a cone of lead foil, rolled up, melted, and cupeled. The "button" is weighed, and the free gold determined by multiplying its weight by 1,000.

The tailings produced in the panning operations should be panned over several times to collect all the sulphurets, which should then be dried, weighed and their percentage in the ore determined.

Another method consists in not separating the free gold from the sulphurets, but in treating them both together by fire assay and determining the total value of the gold present in them. The operations, as far as described, are all that can be properly considered as coming under the term of battery amalgamation as practiced in California, if we except the use of the riffle and blanket sluices; these are placed below all the plates and receive a very spasmodic attention in the majority of mills. Blankets are laid in strips about 16 inches wide and about 6 feet long, overlapping each other in double sets of sluices, set on a grade of about $\frac{3}{4}$ inch to the foot, washed in a separate water box.

The material thus obtained, with the contents of the riffles, is deprived of its valuable contents by the aid of arrastras, pans or Chile mills. But few blanket sluices are found to day in California mills.

On the practical development of the Plattner chlorination process, by Mr. Deetken, in the "sixties," it was demonstrated that many of the low grade quartz veins carried enough gold in their sulphurets to make their working profitable, causing attention to be directed to the concentration of these ores by mechanical contrivances. From the constant and successful use of the gold pan the mechanical application of a similar motion was sought, resulting in the use of the Hendy and similar concentrating machines.

The Hendy concentrator consists briefly of a shallow iron pan with an annular groove on the outer edge and

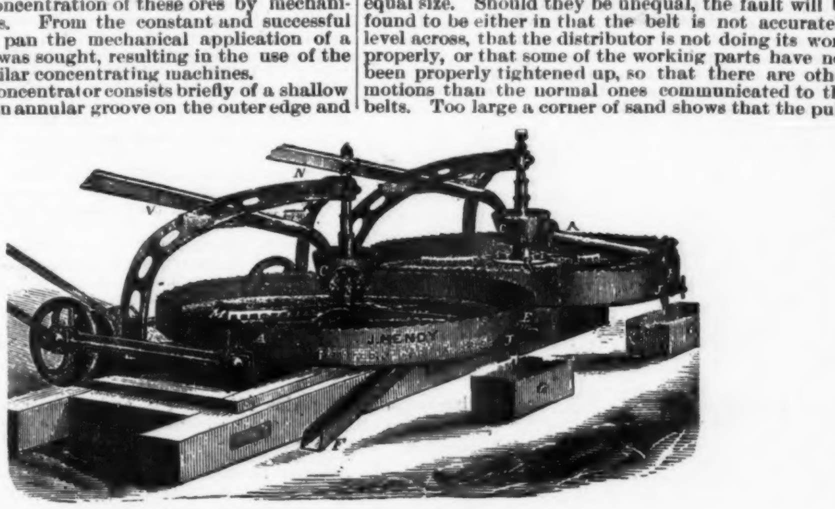


FIG. 36a. THE HENDY CONCENTRATOR.

a waste discharge in the center. It is supported on a central upright shaft passing through the center of the pan, on which revolves, above the pan, a central bowl to receive the pulp, having two tubular arms extending close to the outer edge of the pan; these uniformly discharge the pulp at right angles from their axis. At a point on its circumference the pan is attached to a crankshaft making about 220 revolutions per minute. The sulphurets and small balls of amalgam gather in the groove at the outer edge, from whence they are drawn through a gate, which is regulated to be automatic in its discharge. This gate is not opened until the groove is pretty well filled with sulphurets. Two of these machines, driven by one shaft, are required for a five stamp battery. The machine needs constant attention; one man can attend to twelve machines on a shift. They have been mostly displaced by the endless belt machines which have developed from the endless blanket and shaking table.

In 1867 the first patents for the revolving belt were issued.* This was the commencement of the belt concentrators, of which at present the Frue, Triumph, Woodbury, Tulloch, Embrey and Johnston are representatives. To produce the best results on these machines, all the stuff should be sized.

The Frue vanner (Fig. 37), which has the largest representation in California gold mills, has been frequently described.* It has a side shake of 1 inch,

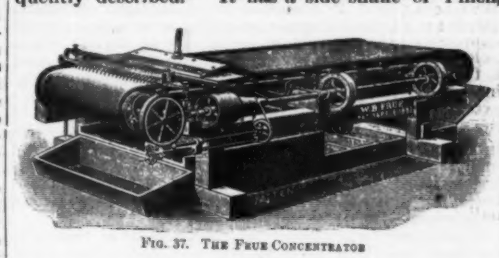


FIG. 37. THE FRUE CONCENTRATOR

with from 180 to 200 strokes per minute, the belt traveling upward on an incline from 3 feet to 12 feet per minute. The belt is made in two sizes, 4 feet and 6 feet wide, and in the latest patterns as made at the Union Iron Works, San Francisco, has practical arrangement for easily changing the slope at the upper end.

The frames of these modern styles are made of iron instead of wood. The pulp is discharged very evenly over the belt from a distributor near the upper end, just below the point where clear water is discharged in fine jets across the belt. In placing the machine, attention must be given to the solidity of the frame, and that a perfect level be obtained across the belt; further, the pulp and clear water must be distributed in an even depth of about $\frac{1}{4}$ inch; the grade and upper travel depend on the fineness of the pulp, and must be regulated accordingly.

The following guide for a proper condition of the work on the belt is given by Henry Louis, E.M., F.G.S., etc., in his very useful work, "A Handbook of Gold Milling," 1894, p. 324: "The working conditions

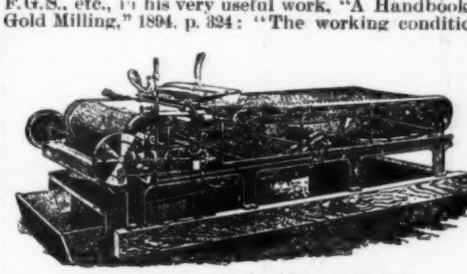


FIG. 38. THE IMPROVED TRIUMPH CONCENTRATOR.

should be so adjusted that a small triangular patch of sand should show at each of the lower corners of the belt. These sand corners should not be too large, but must be well marked, and the two should be of equal size. Should they be unequal, the fault will be found to be either in that the belt is not accurately level across, that the distributor is not doing its work properly, or that some of the working parts have not been properly tightened up, so that there are other motions than the normal ones communicated to the belts. Too large a corner of sand shows that the pulp is too thick, while absence of any corner indicates that it carries too much water."

Two of the 4 ft. belt vanners, or one of the 6 ft., handle the pulp from a five-stamp battery. The amount of clear water required to be added is about $\frac{1}{8}$ cubic ft. per minute; the vanner requires about one-half horse power.

The Triumph differs from the Frue, principally, in that it has an end shake of 1 in. and slightly quicker stroke (230 per minute), the belt making a forward movement of 3 ft. to 4 ft. per minute. It receives the pulp in a bowl containing quicksilver before reaching the distributor, which is all kept in agitation by revolving stirrers.

The Woodbury is similar to the Triumph in extent and number of motions, but divides the belt into seven longitudinal partitions; an increased output being claimed for this construction.

The Tulloch gives a rocking motion from a fulcrum on the floor, making 140 shakes of $1\frac{3}{4}$ in. per minute, using either canvas or rubber belt. This machine, it is claimed, saves a somewhat larger amount of the finer and richer grade of sulphurets as compared with the former types.

The Embrey is similar to the Frue, but with end shake.

The Johnston, with improvements, and the latest of the belt concentrators placed on the market, claims many points of advantage. It is suspended from four

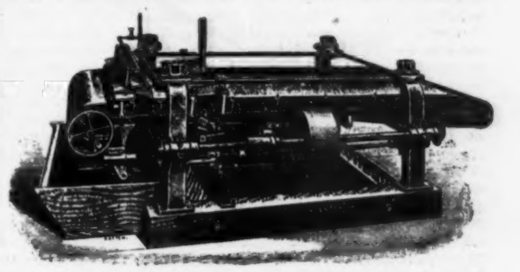


FIG. 39. THE JOHNSTON CONCENTRATOR.

non-parallel hangers capable of adjustment, by which the angle of oscillation can be changed as required, preventing the accumulation of sand at the edges, such as occurs with the horizontal side-shake machines, or the piling of the sands in the center of the belt, that occurs with the rocking motion. The motion imparted to this belt resembles more nearly that of the batea than that of any of the other concentrators. The belt is made of No 6 duck, oiled and painted, but a rubber belt can be used at one-third the cost of those with moulded edges, which are short lived. Small, hollow, brass, side rollers on the shaking frame, form the raised edges by curving the flat belt slightly upward. The pulp is delivered from five slots running parallel with the belt frames, $\frac{1}{4}$ in. wide and 16 in. long, leaving 10 in. spaces, into which the pulp is thrown when it strikes the belt. Here the separation at once takes place; the sulphurets settling on the belt are carried by it up to the clear water, while the sands are carried down the belt. In neither case are the sands or sulphurets obstructed by the falling of water and sands, as in other machines where the pulp is discharged across the belt. The clear water at the head of the table, instead of being discharged from a stationary box to the moving table, is discharged from a distributor, which is attached to and moves with the table, thus stripping the belt of the smallest possible portion of sulphurets. Two widths of belt, 54 in. and 72 in., are used, which are given a grade of $\frac{1}{8}$ in. to $\frac{1}{4}$ in. to the foot, making about 118 side shakes per minute. One machine handles the pulp from a five-stamp battery.

Another vanner, soon to be placed before the mining public, consists of the essential features of the vanner, but carries a rubber belt with depressions all over it, 2 in. in diameter and $\frac{1}{8}$ in. deep, shaped after the batea, while the entire belt receives a motion corresponding to that given to a batea.

As the motion and grade given to any of these machines can only be correct for a certain size of grain in the pulp, it would be advisable to introduce some method of sizing the pulp previous to bringing it on the concentrator, and feeding the sized material to different machines. The finer the screen that has been used in the battery, however, the less does the lack of sizing affect the product from the concentrators. The concentrators should always, where possible, be attached to power independent from the stamps, and be placed on the floor below the aprons and in a position to permit the attendant to pass all around and to conveniently transport the concentrated stuff to the covered drying floor, which should be made with a slight incline, preferably of concrete, and exposed to the sunlight.

Canvas Platforms or Tables.—Investigation proving that the slimes passing off with the waste from the mill and concentrators still carried an appreciable amount of precious metal, millmen during the last few years have extended their operations, and retreat the hitherto escaping slimes. This is done by conveying all the waste material from the mill, through sluices, to canvas platforms having the following general features. (See illustrations in chapter on "Typical Mills.")

A platform is built of clear, seasoned, and planed, $1\frac{1}{4}$ in. planking, on a solid, level foundation, and given a grade of about $\frac{3}{4}$ in. to the foot, over which No. 6 canvas is stretched smooth longitudinally, though sometimes crosswise, with a 2 in. overlap. Particular attention must be paid that the canvas is stretched smoothly and evenly and that no crack opens between the planks constituting the platform. The length and width of the platform required depends on the amount of pulp to be handled; overcrowding must be avoided. The platform is divided longitudinally into sections corresponding to the width of the canvas, which is 22 in.; the partition is made of wooden strips, 2 in. wide and $\frac{1}{2}$ in. high, covering 1 in. on the edge of two adjoining pieces of canvas. Running along the head of the platform are two sluices, one placed above the other; one containing clear water, the other pulp from the mill, both furnished with $\frac{3}{4}$ in. to 1 in. plug holes over each section. Below the lower edge of the platform are two sluices placed side by side, the inside one to convey the waste, the outer one for the concentrates (sweepings) from the platform. When ready for operation, the plugs are withdrawn, and both pulp and clear water commingled flow down in an even current and are discharged through the bottom waste sluice. After one hour or less, the plug is inserted in the pulp box over the first section, and the clear water permitted to run for a few minutes longer, during which time quartz sand may be observed passing off the canvas, leaving a dark, partly metallic appearing sediment on the canvas. A tray or board is then placed over the waste sluice, connecting the lower edge of the section with the outside sluice, and the sediment is removed from the canvas, either by sweeping or with the aid of a hose with a flattened nozzle, to be worked later by chlorination or cyanide process.

The following is a description of an improved canvas plant erected and operated in Amador County, by the patentee, Mr. Gates. In this case the pulp

* From the records of the United States Patent Office.

No. 61,426, January 22, 1867. T. D. & W. A. Hedger, Meadow Lake, California. "Revolving sluice for saving metals."

. . . "The endless apron is made of fabric sufficiently coarse to retain the heavier particles which it receives from the feed spout, beneath which issues a stream of water."

Claim 3. . . . "Separating the ore by passing the valuable portion up the incline and the debris down to the foot, as waste matter, as described."

No. 66,499, July 9, 1867. George Johnston and Edwin G. Smith, Auburn, California. "Amalgamator and concentrator."

. . . "The pulverized ore or tailings passes to an endless traveling and shaking canvas belt, which ascends against a stream, carrying the heavier particles to be discharged into a box, while the lighter ones are carried off." . . .

Claim 1. The revolving belt or apron (F), with its raised edges (O), having a shaking or rocking motion from side to side, substantially as used for the purpose herein described.

No. 239,091, March 22, 1881. Judson J. Embrey, Fredericksburg, Va. "Ore concentrator."

* See VIth Report of State Mineralogist, p. 92, article on concentration, by J. N. Adams, E.M.; and VIIIth Report, p. 718, "Milling of Gold Ores," by J. H. Hammond, E.M.

and waste water are conducted from the mill in a flume to the plant, and there divided into two equal streams by the insertion of an adjustable division plate in the flume. The divided pulp passes into boxes (see Fig. 40) 4 ft. long and 1 ft. wide, and having steel

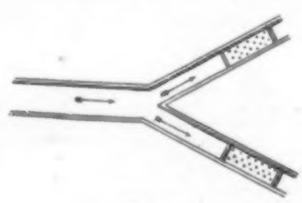


FIG. 40.

screen bottoms with ⅛ in. and 1/16 in. perforations, set on a reversed grade of 6 in. to the box. The object of these screens is to prevent any chips, leaves, lint, or foreign substance from passing into the sizing box (Fig. 41) beneath, which consists of a wooden V-shaped trough, 6 ft. long, 15 in. broad at the top and 2 in. in the bottom, constructed of 1½ in. boards. A piece of canvas is tacked on the bottom for packing; underneath is nailed a piece of scantling, 4 in. × 6 in., at one end of which, reaching within 2 in. of the end of the box proper, a slot, 14 in. long and 2 in. broad, is cut; here a flattened, galvanized iron funnel, ending in a 2 in. pipe, is attached. The pulp falls through the screen with some force and is considerably agitated in the separator box. Naturally the coarser and heavier particles have a tendency to settle toward the bottom. Were the outlet there large enough, all the pulp would pass down and out. Its size of 2 in. causes the box to fill to the height of a sluice box in the end, through which the finer pulp flows to the canvas tables. To facilitate the separation, a device is placed in the lower end, consisting of an iron pipe, ½ in. inside diameter, connected with the main pipe above the screen, and divided into two sections, which are connected by rubber hose for ready detachment. The lower 6 in. of the iron pipe has small perforations, through which clear water is ejected, causing an agitation of the pulp. The end of the pipe is stopped with a wooden plug, easily removed. The agitation at the end of the pipe causes the fine material to be carried upward and into the sluice at the end of the separator box. Only coarse sand passes through the bottom pipe, and on examining this with a magnifying glass, very few particles of sulphurets are discernible. This separator works well, and disposes of a lot of coarse, valueless material that would otherwise interfere with the subsequent working of the slimes on the canvas platforms. The fine pulp flowing from the top of the separator is conducted in a sluice to a broad, flat box, in which the stream is divided by partitions into ten separate currents, each terminating over a canvas table, ten in a row. The pulp goes over a spreader made of strips of galvanized iron, ¾ in. in height, radiating from a common center to the farthest side of the table, which is 12 ft. wide. These strips are nailed to an inclined board extending across the canvas table, having an iron strip, 1 in. high, fastened to the lower end, perforated or notched, with indentations 1/16 in. deep and 1 in. long, affording a perfect distribution. Twenty tables are arranged in two rows of ten each, covered with canvas laid crosswise and overlapping about 2 in. These tables have a grade of 1½ in. to the foot, are 13 ft. long and 12 ft. wide. After receiving the flow for an hour, it is shut off from the table and a flow of clear water turned on which in a few minutes washes away the sand, when it is also stopped; then with a hose ending in a flat nozzle, the accumulated sulphurets are washed from the canvas into a trough below, extending along the base of the entire series. In order to secure sufficient fall for this sluice, each succeeding table is set 4 in. lower than its predecessor, giving 40 in. fall on 125 ft. of sluice length. Two extra tables are arranged, one at the end of each row, to take up the surplus flow during the time one of the tables is shut off, to avoid overloading, as each table already carries the proper amount of pulp. The effectiveness of the canvas tables depends on maintaining an even flow of pulp during a given time; it will not do to overload them. All the pulp that leaves the table is considered waste, and is collected in a flume, to be used a short distance off as a power on an overshot wheel, by means of which the patentee runs a vanner of his own invention. This waste water is caught up again and used on a second wheel, which also runs a vanner. The sulphurets washed from the tables flow through a sluice to a box outside the building, 12 ft. long, 2 ft. wide, and 12 in. deep, with a cross piece 2 ft. from its upper end, reaching within 2 in. of the top of the box; in this upper section the coarser grade of the material is retained, while the finer flows over the weir. The two grades are shoveled out separately and placed in separate V-shaped boxes, over which are perforated iron pipes, from which small streams of water trickle, gradually carrying the pulp down and passing it through sluices onto the spreaders of separate vanners. These two machines work with different motions, doing excellent work on this impalpably fine stuff. The slimes flowing from the washing boxes beneath these vanners are conducted, with the overflow of the two compartment boxes above referred to, to two other canvas tables, below which they are allowed to escape as waste; not that they have given up all the precious metal they carried, but because the point is reached where it is more economical to lose the remnant than to attempt to save it.

As the slimes from most of the canvas plants, as usually operated (especially where the ore crushed carries a heavy percentage of sulphurets, or has been stamped with a high discharge), are still valuable in gold, they can be conveyed to so-called slime settlers, or tanks. These tanks, for there are generally several, are placed below the canvas platforms, and are about 2 ft. deep, 2 ft. wide, and 12 ft. to 20 ft. long; they are divided into sections of 2 ft. square, by 2 in. planks set on edge, extending alternately from each side, leaving an opening 4 in. wide and 2 ft. deep, causing the slime water to take a serpentine course in passing through. The tanks stand level, and the slimes, in settling, form their own grade as they enter at one end of the tank, and, passing through the successive sections, issue at a diagonally opposite point only slightly clouded. These tanks require cleaning only at long intervals.

Up to the present time, the concentrates in the California mills have been generally handled by the chlorination process, to free them from their gold, but within the last year several plants are successfully working them by the cyanide process.

The tendency in the construction of mills at the present day is to a substitution of steel for iron, where possible, and to an increase in the weight of the stamps.

A greater application of grinding and amalgamating machines, in place of or subsidiary to the stamp mill, is also noticeable, the most popular of which will be shortly described.

For a more thorough appreciation and knowledge of the work done by mills, records should be kept, by the amalgamator, of all transactions connected with mill work, showing every item, loss of time, consumption of mercury, iron, fuel, water, amount of rock treated, etc., in addition to the records kept in the assay office. This is already being done to some extent, but such records should be kept in the small mills as thoroughly as in the large ones.

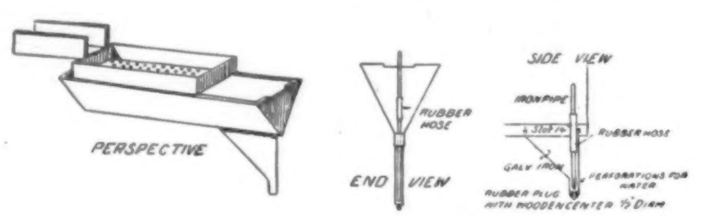


FIG. 41. SIZING-BOX

(To be continued.)

THE CHEMISTRY OF OXIDES USED IN THE MANTLES FOR INCANDESCENT LIGHTING.

THE London Journal of Gas Lighting furnishes the following translation of an article by Dr. G. P. Drossbach, which forms the sequel to a previous article by the same author: *

Thorite has recently come into notice as a raw material, and appears in the market more often than it did. The supplies of Brevig, Arendal, Hitteröe and Champlain appear to have been quite exhausted; but it has been found elsewhere, and now can be purchased, with a content of 40 per cent. of thoria, at £17 10s. and under. Among recent analyses of thorite, Nilson's are the most reliable, and he found that selected crystals of the Arendal mineral contained: Silicic acid, 17·04 per cent.; phosphoric acid, 0·86 per cent.; thorium oxide, 50·06 per cent.; uranous oxide, 9·78 per cent.; lead oxide, 1·67 per cent.; ferric oxide, 7·6 per cent; oxides of the cerium group, 1·39 per cent.; lime, 1·99 per cent.; magnesia, 0·28 per cent.; and water, 9·46 per cent.

For preparing pure thoria, Nilson takes the impure thorium oxide prepared by Berzelius' method, and converts it into sulphate by warming with concentrated sulphuric acid. This he dissolves in 5 parts of ice cold water, and on warming the solution to 20° C. a copious deposit of snow-white thorium sulphate is thrown down. This operation is repeated until thoria of constant molecular weight is obtained. A single recrystallization may not be sufficient. The sulphates of the cerium group are soluble with difficulty in hot water, and are partially deposited with the thorium sulphate. The solubility of thorium hydrate in alkaline carbonates affords a rapid means of separation, care only being taken that the cerium is present as oxide, which is insoluble in dilute alkaline carbonates.

Recently an intermediate commercial product, known as thorium precipitate, has begun to compete with thorite. It is technically a hydrated thorium oxide, containing from 86 to 88 per cent. of the oxide, and is dealt in at about £14 10s. per pound, or £16 10s. per pound of thorium oxide. Compared with other commercial products, this hydrate is very pure, and it is therefore very easily worked up. A pure oxalate is obtained on precipitating a hydrochloric acid solution of the salt, and, by ignition, the oxalate is very easily converted into pure thoria.

Monazite still, however, is the most important material, and has only the above-named hydrate as an active competitor. The most varying qualities are found in commerce. Many dealers sell according to sample, but deliver very different materials; while others sell according to the percentage of monazite, trusting to the latter being estimated by the content of yellow nodules, which are not, however, all monazite. One Dutch tender is for 70 per cent. monazite at 8 cents per pound; but actually the sand often contains only 50 per cent. As methods of estimating the percentage of monazite are not established, I propose the following means of valuation:

The very finely powdered monazite sand is heated in a platinum crucible, with three times its weight of sodium potassium carbonates, until in a state of steady fusion. The melt is extracted with water; and silica separated from the aqueous solution in the usual way with hydrochloric acid. The insoluble residue is treated with concentrated sulphuric acid, and the sulphates dissolved in ice cold water. [It is not practicable to dissolve the monazite in sulphuric acid at an earlier stage, as one treatment with the acid does not always break up all the monazite.] The residue is taken as chrome ironstone. Excess of oxalic acid is added to the sulphuric acid solution; and the precipitate formed is carefully washed, filtered, dried and ignited. One hundred parts of the oxides obtained correspond to 142 parts of monazite, as selected monazite crystals constantly yield 69 to 70 per cent. of the oxides.

The filtrate from the oxalic acid precipitation is treated with ammonia, and the precipitate taken as foreign oxides. It is evident that the determination of the oxalic acid precipitate is sufficient; but it is useful as a check to know the impurities also. The sum of the constituents usually amounts to 102 to 103, instead of 100, because by ignition a portion of the cerium sesquioxide is converted to cerium dioxide. In order that no didymium may remain in solution on the precipitation with oxalic acid, it is necessary that the original solution should not be very strongly acid, and especially that it should not contain a considerable amount of nitric acid.

Now that thorium oxide is very commonly dealt in according to its percentage, in which variations occur, it is desirable that there should be a recognized method of estimation. This must be based on the composition of monazite. According to Penfield, the thorium of monazite is derived from admixed thorite. He comes to this conclusion, because there is about the same proportion of silica to thoria in monazite as in thorite. But my own experiments show that the whole of the thoria cannot be extracted with hydrochloric acid from very finely powdered monazite, as would be the case if it were present exclusively as thorite. According to Hidden, Kerr, Geuth, and others North American monazite sand contains the following minerals: Monazite, tetradymite, brookite, quartz, chromite, anatase, beryl, tourmaline, pyrope, zircon, epidote, fibrolite, columbite, samarskite, xenotime, montanite, fergusonite, rutherfordite, talc, tremolite, magnetite, limonite, menacanite, hematite, tellurium, asbestos, cyanite, corundum, rutile and actinolite. But as far as I have observed, only quartz, albite, chromite, magnetic iron ore, garnet, samarskite, aeschynite and zircon are present, though, of course, often in a state of impurity.

A complete analysis of so complex a mineral substance is not desired and, indeed, is scarcely practicable. Beyond the impurities of Brazilian monazite—consisting chiefly of quartz, chrome ironstone, magnetic iron ore and zircon—the estimation of the chief constituents must generally suffice. I propose the following as a method for general acceptance; it has proved satisfactory in more than a hundred analyses. The same course is pursued as in the estimation of the monazite, and the mixture of oxides of the cerium group is taken for further examination. Too high results would be obtained if the thoria in this mixture were estimated by Lecoq's method, as a portion of the cerium would be separated with it on precipitating from a neutral solution. It is better to proceed thus: The mixture of earths is intimately mixed with lampblack, and heated in a stream of chlorine. Thorium tetra-chloride volatilizes, while the metals of the cerium group remain as difficultly volatile chlorides. The thorium chloride so obtained (20 to 50 grammes of monazite are taken) is dissolved in water acidified with hydrochloric acid; the solution is neutralized, and the thorium oxide is precipitated by Lecoq's method, by boiling with hydrated cuprous oxide. By again taking up in dilute hydrochloric acid, precipitating traces of copper with sulphureted hydrogen, and then precipitating the thoria with oxalic acid, and filtering, washing and igniting, pure, snow-white thorium oxide is obtained. If the remaining oxides in the monazite are to be determined, the filtrate from the thoria precipitate is precipitated with oxalic acid, and the precipitate is purified with the bulk of the oxides of the cerium group, the oxalates being converted to oxides by ignition.

It is commonly supposed that the oxides of the cerium group may be separated from those of the yttrium group by precipitation with a concentrated solution of potassium sulphate. But Popp has proved that this separation is not only incomplete, but that oxides of the yttrium group are found in the precipitate of double sulphates. He was led by this to the erroneous conclusion that erbium is identical with didymium. In reality, nearly all the erbium goes into the precipitate on treatment with potassium sulphate and the subsequent treatment leads to its inclusion with the didymium. A similar fate befalls scandium, terbium and the yttrium group metals with absorption spectra—particularly decipium, samarium, Marignac's $Y\alpha$ and $Y\beta$ oxides, as well as thulium and holmium. It is not surprising that Kruss suspected the presence of a dozen metals in crude didymium. The solubility of the yttrium metals (as distinguished from cerium, lanthanum and didymium) in alkaline carbonates was tried as a means of separation, but it was found generally that they remained in solution for a short time only, and were again thrown down tolerably soon.

My experiments indicate that these oxides may be retained in solution by using a very large excess of very concentrated potassium carbonate, in the presence of salts of ammonium. On acidification and addition of oxalic acid, the oxalates are thrown down. After careful washing, these oxalates are brought into a boiling saturated solution of ammonium acetate containing a surplus of undissolved salt, filtered while hot and washed with a hot concentrated solution of ammonium acetate. The filtrate is very greatly diluted and hydrochloric and oxalic acids are added for precipitation. There are thus separated from the filtrate a great quantity of oxalates of elements giving absorption spectra, while the residue on the filter contains, besides didymium, no oxalates giving absorption spectra. Let us call the residue on the filter Y, and the precipitate from the filtrate E. The first contains, besides cerium and a little didymium, a number of oxides of the yttrium group without absorption spectra; the precipitate, E, all the elements yielding absorption spectra, besides traces of didymium, which, however, may be absent. Y and E contain a series of new elements, which may be traced by the recrystalli-

* See American Gas Light Journal, October 7, 1895, p. 567.

zation and fractional precipitation of some kilogrammes of these fractions, and amount to 20 to 30 per cent. of the mixture. Work on a very large quantity of these fractions (about 30 kilogrammes) is now in hand, and I would ask that this investigation should be left to me.

Schottländer has published some exhaustive work with regard to the separation of cerium, lanthanum and didymium. He states that separation of cerium from lanthanum and didymium is best effected by Auer's method. I cannot confirm this, as I found Popp's system to excel it in simplicity and certainty. The neutral solution of the mixed chlorides is largely diluted, and sodium acetate and sodium hypochlorite added. As the cerium dioxide separates, the free acid must be neutralized. In this manner it is easy to obtain all the cerium. The separation of didymium and lanthanum is best carried out by Frerich's (Deutsch. Chem. Ges., Ber. VII, p. 798) or Auer's (Monatsh. Chemie, IV, p. 630; V, p. 508) method. It would seem that, in all reported analyses of monazite, everything soluble in alkaline carbonates has been taken as thoria; everything not precipitated by potassium sulphate, as yttrium and erbium oxides, and the residue stated as oxides of the cerium group.

A large number of minerals, of which, until recently, few collections boasted specimens, are now found on the market in considerable quantities. For instance I have in hand a quantity of auerlite—a mineral discovered by Hidden and Mackintosh. I believe it is a very pure orangite, as the proportion of phosphoric acid is not constant. Very large quantities of tscheffkinite lately came on the market from Virginia. This is a mineral of very complex composition, containing titanates of the rare earths. Gummite, containing thorium, is said to be found in Carolina; but as far as I am aware, it is only obtained in Texas. Uranite containing thorium (and helium) is brought from Connecticut, and has recently been found in Bohemia very rich in thoria. Gadolinite is not in demand, and is very cheap. Yttrialite, with 8 to 10 per cent. of thoria, is obtainable in considerable quantities; and fergusonite, containing 3 per cent. of thoria, comes to the market in very large amounts.

Though sufficient to meet the demand, the quantity of thoria produced is still relatively small. Since thorite has again entered into commerce, very few firms work up monazite, and the price of it has steadily declined. The cargoes of monazite mentioned by E. Glinzer, which arrived at Hamburg, were for Vienna. All the Welsbach companies procure their fluid from the Vienna firm for £5 per kilogramme nominally, and an additional payment of £2 per kilogramme until lately. The fluid (which is a nitric acid solution of the oxides) contains 280 grammes of nitrate per kilogramme, which is sufficient for 250 mantles. One kilogramme of the nitrate costs the companies, therefore, £22 10s. to £25, while in the open market pure thorium nitrate still costs £27 10s. to £30 per kilogramme. One kilogramme of the nitrate will produce 900 to 1,000 mantles; so the cost for material is about 7d., and the total cost about 10d. per mantle.

The stoutness of the threads and the size of the mesh in proportion to the mantles is important in the manufacture of the latter. In good specimens the thread is 0·2 mm. (0·0079 inch) in thickness, and it should be of absolutely pure cotton, as free from ash as possible. Mantles which come on the market at a price of about 1d. are quite unsuitable for use. Their content of ash is far too great, and filaments purified with hydrochloric and hydrofluoric acids cannot be made at the price. For really durable mantles, fulfilling the highest claims, a thorough preliminary purification of the filament is indispensable. Absolutely pure thorium nitrate occurs in commerce, and may be mixed with one-fourth to one-fifth of terbium and yttrium nitrates, and applied as a 30 per cent. solution. For a greenish light, an addition of 5 per cent. of erbium nitrate is necessary; for a yellow light, lanthanum nitrate. Moreover, the kind of burner has a considerable influence. The original Welsbach burners are, perhaps, the most unfavorable to the light. The mantle only is far superior to all others. The Welsbach burner gives, with good gas, a flame only partially luminous if the chimney is removed. Many burners considerably raise the efficiency of the Welsbach mantle. It is only a technical question how to increase the intensity of the development of heat sufficiently for the employment of the cheaper oxides allied to zirconia for incandescent lighting.

[FROM THE SOCIAL ECONOMIST.]

THE LEGAL MERITS OF VENEZUELA'S CASE.

THE Spanish in the new world retain much of the uncompromising spirit of the old grandees of Castile and Aragon. Their environment is American, and of the new world; but their pride and adhesion to old landmarks and traditions maintain them in close alliance to their Spanish ancestry, who would risk but little and yield nothing. This is apparent to any one who candidly examines Executive Document, No. 226, of the 50th Congress, First Session, in which the President transmits to Congress the documents relating to the pending dispute between Venezuela and Great Britain concerning the boundaries between British Guiana and Venezuela.

American editors and some American statesmen have freely assumed that because Great Britain has might on her side therefore Venezuela must have the right on hers, or there would be no contest. Weak powers do not usually stir up groundless strife with strong ones. But we discover on the perusal of these documents that the essential boundary question, with the same merits as it possesses to-day, has been pending 315 years. During an early stage of this dispute the rights now belonging to mighty Great Britain then belonged to the little and weak Netherlands, who were at that time in some sort of national freedom or partial vassalage to Spain.

The rights now held by little Venezuela were then held by mighty Spain, under its great Philips, from Philip II to Philip V; yet when the power was thus reversed and the kings of Spain could, with their little finger, have easily bent the claims of the Netherlands in South America to suit their will, they did not drive out all the non-Spanish occupants of the territory between the Essequibo and the Orinoco, nor compel their allegiance to Spain. This task, which Spain in the zenith of her power would not perform against a petty state which was for a time her vassal, the United States are now asked, in the name of the Monroe doctrine, to do on behalf of Venezuela. Nearly three centuries have passed since Spain permitted the adverse possession of the Dutch to begin, and every year of the intervening time has tended to strengthen the possessory title, against which we are now asked to insist upon arbitration or to take up arms.

Of course it requires careful examination of the documents to ascertain that this is the true state of the case. But when the actual facts have thus been arrived at, the principle of international law that governs it is clear.

Spain discovered America and particularly the whole coast of Venezuela and Guiana, and so obtained a clear right to settle and colonize any and all parts of that coast. This was an inchoate right of property which would become absolute jurisdiction whenever and wherever her subjects founded colonies and held possession. Spain actually colonized and settled or established missions on the Orinoco shortly after 1531. Some of her missions were in the now disputed territory, but the Spanish built no forts or towns and carried on no permanent industries in the part of the coast lying between the Orinoco and the Essequibo, though her troops or expeditions made two efforts to drive out the Dutch settlers who had done so. From the first, therefore, as early as 1580, it was a question between Spanish abstract right to colonize, acquired by discovery, and Dutch actual possession, acquired by occupancy at points which Spanish settlement had left open and vacant.

In support of Venezuela's right, her diplomats, on page 27 of Doc. No. 226, quote Vattel on the Law of Nations, Book II, ch. 7: "Everything included in the country belonging to the nation and nobody besides itself, or he to whom it has devolved its right, being able to dispose of it. . . . If it has left uncultivated and desert places in the country, nobody has the right to take possession of them without its consent. Although it makes no actual use of them, these places belong to it, it has an interest in preserving them for future use, and ought not to be accountable to any person for the manner in which it makes use of its property."

This text refers to the waste places in an old country whose settlements surround and contain these waste places, and not to the unoccupied parts of a new continent like the Guianas, Barima, Moruca and Pumeron coasts in 1598. This is plain from such other texts of Vattel as the following (Book II, ch. 7):

"It may happen that a nation may be contented with possessing only certain places or appropriating to itself certain rights in a country that has not a master, and be little desirous of possessing the whole country. In this case another may take what the first has neglected; but this cannot be done without allowing them an entire and absolute independence with respect to all the rights acquired by the first." Again (ch. 11) Vattel says: "We ought not then to consider property as so extensive and secure a right that it can be absolutely neglected during a long space of time, notwithstanding all the inconveniences that may happen to human society by the proprietor resolving to make use of it according to his caprice. Why does the law of nature order all to respect this right of property in him who possesses it, if it is not for the peace, safety and advantage of human society? Nature must, then, from the same reason, require that every proprietor who, for a long time, and without any just reason, neglects his right, should be presumed to have entirely renounced and abandoned it. This is what forms the absolute presumption or juris et de jure of its being abandoned, and upon which another is legally entitled to appropriate the thing abandoned to himself." Again, "Usucaption and prescription (title by possession and length of time) are founded in the law of nature, are equally a part of the law of nations and ought to take place between different states. So far is the nature of the subject from forming any exception, that usucaption and prescription are much more necessarily used between sovereign states than between individuals. . . . Were it permitted to have constantly recourse to ancient times, there are few sovereigns who would enjoy their rights in security, and there would be no peace to be hoped for on earth."

With law thus made clear, it is easy to see what is the effect of the facts. Not one of the lawyers commissioned by Venezuela to speak for her claims that, since the first few priests followed the discoverers into the country in dispute in 1531 as itinerant missionaries to the natives, and not as settlers, there has been any settlement or colonizing by the Spanish of ever so small a part of the country between Punta Barima, at the mouth of the Orinoco, the extreme western point to which Great Britain claims, and the Essequibo. Nor do any of Venezuela's diplomats (Calcano in 1876, Camacho in 1880, Seijas in 1882, and Soteldo in 1885) fail to admit that what they call the "intrusions" of settlers, resident population, or armed, forcible and continuous occupiers, into the now disputed territory from 1585 to date, have always been made by Dutch and English, as an overflow from what is now British Guiana, except when, on two occasions, 1595 and 1665, the Spanish temporarily drove the Dutch across the Essequibo, and on a third occasion, 1797, they were repulsed in the effort to do so. Even these successive attempts to dislodge them, too, prove their continued occupancy. Had the Dutch troops come into the same territory on a like errand, they would have found no Spanish population to dislodge.

It is Mr. Seijas on behalf of Venezuela who, on page 26 of the document alluded to, says that in "1596 they (the Spanish) immediately drove the Dutch from it (the Essequibo) who attempted to cross it;" also that "in 1779 a Spanish commissioner sent to investigate" found that the Dutch had in Moruca a post, although insignificant, since it only consisted of two dismantled cannon and some swivel guns, and he recommended, however, for the security of the new settlements which might be made [but never were.—Ed. Econ.] "the dislodgment of the Dutch from said post."

While Moruca is but a few leagues west of the Essequibo River, the maintenance of a fort there a century ago, which the Spanish resolved to capture but did not, along with other settlements, forts and trading stations at different and often earlier dates, from the Barima and Barama Rivers to Punta Barima on the Orinoco itself, serves to spread the continuous and uninterrupted occupation by the Dutch directly across the coast line in front of the whole territory in dispute.

Whatever country owns the coast line may run any reasonable line from its coast back to the interior. The utmost line claimed by Lord Salisbury runs from this point, Barima, southward along the line of the nearest mountains to Brazil. Modern example and precept justify the selection of mountain summits as better than rivers as boundary lines, since the former make a more natural barrier between populations, while rivers are almost sure to gather homogeneous populations on both their banks. It is a fact worthy of note that the Venezuelan map, published by authority of the Venezuelan government and furnished by it to our own government, notes down every Venezuelan hamlet and town, but they all fall outside of the farthest line drawn by Schaumburgk, Aberdeen, Granville or Salisbury as the outer line of the British frontier. But within the disputed territory, though it contains nearly as large a population as Caracas, the Venezuelan map notes no settlement or town whatever. The Venezuelan government fails to note on its official map of the territory in dispute the towns and settlements which now occupy it, but maps it without the population marks which are required to make the map a true and accurate map. The producers of such a map in a court of justice would be at an evident disadvantage.

Against the case made on behalf of Guiana by an uninterrupted possession for three hundred and ten years, Venezuela opposes the charge that the whole of this possession was usurpation, intrusion and violation of treaties, and their diplomatists insist that a good title cannot be obtained by prescription or lapse of time where possession is wrongfully usurped in the first instance. Unfortunately for the Venezuelan contention, the whole purpose of prescription is to cut off inquiry into the question whether the original acquirement of possession was with or without right. If it could not do that, it would not be in itself a valid and peremptory source of title.

But our citations from Vattel show that the occupancy of lands left vacant by an original discoverer is neither a usurpation nor an intrusion, but the beginning of a lawful title. If the Dutch could get no title by occupancy to coasts which the Spanish had merely discovered, but had not settled, then, as Lord Aberdeen remarks (p. 30), the English could have no present right to any part of Guiana, as it was all first discovered by Spaniards, and only belonged to the Dutch by occupancy, or what the Venezuelans in their present argument would be compelled to call "usurpation."

The treaty of Munster, made between Spain and the Netherlands in 1648, is strongly quoted by Venezuela as binding the two states, each to leave the other in possession of the territory in America which it was then occupying. The historians and geographers, maps and travelers of the period between 1648 and 1799 are only in seeming conflict. About an equal number and weight of all those sources of information represent the territory in dispute as Spanish by right or as occupied by the Dutch, both of which are consistent. The only occasions between 1580 and 1797 when the Spanish intervened at any of the points in the disputed territory were when they came with the strong hand to drive out the Dutch who had made their homes there. But though the Spanish government ordered towns and forts to be built at various points, they were never built, and no Spanish or Venezuelan populations seem ever to have occupied any part of the disputed territory. The Venezuelan commissioners virtually admit the plea of Lords Aberdeen and Salisbury that the occupation has never been Spanish, in the following words (p. 32):

"To deliver up territories in which populations have been founded cannot help producing grievances, in that all the world is in accord. But the convenient is not the right, neither can it be confounded with it. He who has occupied a thing not his own remains with the obligation to restitute it whenever it is demanded of him, and to indemnify all the damages consequent upon the illicit act."

This bases the whole Venezuelan case on the bald and single issue that Spanish discovery gives not merely the first right to occupy, and by occupation to acquire, title, but that it gives, without occupation, a perfected title which makes all occupation by others perpetually wrongful.

Such a pretense is in contradiction to the clear teachings of Vattel and of every other writer on the law of nations. Indeed, it contradicts the plain principles of common sense.

The Venezuelans have offered on two occasions to run the boundary line in a manner which would give British Guiana more or less territory on the western bank of the Essequibo. Lord Salisbury declines to arbitrate so much as is conceded by one of these offers.

If the line should be run as demanded by Lord Salisbury in 1880, from Point Barima, on the mouth of the Orinoco, where the Dutch seem to have had their fort from about 1589 to 1768, no American statesman could declare that it involved a claim not justified by nearly two centuries of exclusive Dutch possession. If the line should run thence to the nearest mountain tops, follow them to the river Cuyuni and up that river to Brazil, it would be a logical and severe line; but it does not appear that it would involve the surrender by Venezuela of any of her own population to English rule. On the contrary, the surrender of this territory to Venezuela would abandon 40,000 British and descendants of Dutch residents to a Spanish jurisdiction which they have for centuries refused to acknowledge.

Mere discovery does not give a perfected title. It gives only a prior opportunity to obtain a title by occupying. In this case the Spaniards have always claimed but never occupied. The movement into a country to reside there, of a population acknowledging a national jurisdiction is necessary to perfect a national title to the country.

We are wary of uttering a word in behalf of British pretensions to foreign territory, for we are deeply sensible of the aggressive tendency of British diplomacy in all parts of the world. They have ever been hungry

for conquest, and assert their title to ownership, and enforce their claims, especially against weak nations, on the slimmest evidence. In all such matters England's policy is to give itself the benefit of the doubt; but in the present case, so far as official documents throw any light on the subject, the facts are against the Venezuelan claim. To be right is better even than to be against the British.

ALEXANDRE DUMAS.

ALEXANDRE DUMAS the younger, who died in Paris November 27, 1895, was born in the same city on July 28, 1827. He was the son of Alexandre Davy Dumas, novelist and dramatic writer, who was known as Alexandre Dumas the elder, who died on December 5, 1870. The younger Dumas's education was begun at the Goubaux school. Then he went to the College Bourbon, where he made a creditable record, although he was not a brilliant student. He left college when he was seventeen and soon after published "Les Péchés de Jeunesse," a collection of poems of no especial literary merit. In the society of authors and artists, to which his father's position had introduced him, however, he was a favorite because of his precocity and vivacity.

After the publication of his volume of poems he traveled with his father. They went to Spain and afterward to Africa, and after their return young Dumas wrote a novel, the "Adventures of Four Women and a Parrot." This, published in 1846, was not a remarkable success.

At this time Dumas became acquainted with Marie Duplessis, whose story he embellished and published in 1858 under the name of the "Dame aux Camellias." This created a great sensation, and became one of the best known productions of the day. It was written first as a novel, and attained such a success that Dumas dramatized it. The play was at first interdicted, but in 1852 it was produced at the Vaudeville and won an instant triumph, the first Dumas made as a playwright. That made his reputation, and was probably his greatest success. Reproduced in Verdi's opera "Traviata," it created a still greater sensation.

Dumas was exceedingly prolific both of plays and novels, his greatest successes being "Le Fils Naturel" (1858), "L'Ami des Femmes" (1864), "Les Idées de Mme. Aubray" (1867), "La Princesse Georges" (1871), "La Femme de Claude" and "Monsieur Alphonse" (1873), "L'Etrangère" (1877), "La Princesse de Bagdad" (1881), "Denise" (1885), and "Francillon" (1887). "La Femme de Claude" was a dramatic version of his novel "L'Affaire Clemenceau."

An English critic has said of him: "Dumas moralized the theater. As that is his best, and will be his most enduring work, I have thought it the right side of him to dwell on. He had, of course, many other sides. He was an adroit craftsman; he had an admirable dramatic style, a scintillant wit. He was not a very profound philosopher—playwrights seldom are. It is not by his ideas that he will live; but because he was earnest, because he raised the theater from a toyshop to a school of conduct, because, in short, he was essentially a good man, we deplore his death, and should keep his memory green."

Dumas was made a member of the French Academy on January 30, 1874, succeeding Pierre Lebrun. Victor Hugo appeared for the first time at a meeting of the "Immortal Forty" after his return to France in order to vote for Dumas, who was elected by a vote of 22 to 11. Within the last year he was made Grand Officer of the Legion of Honor. Dumas's house was filled with paintings and bric-à-brac. In 1892 his collection of paintings was sold for more than $100,000.

For our illustration we are indebted to the Illustrated London News.

ALEXANDRE DUMAS.

CHIEFS OF THE FIRST CUBAN REVOLUTION.

WE publish the portraits of these three Cuban enemies of Spain. The papers have carried and published their names for some time past, and we feel obliged to satisfy the curiosity of our readers in regard to this subject, which is of the greatest importance as relating to the war in Cuba.

Enrique Collazo was in Spain when he was young, and was an alumnus of the Academia de Artilleria, of Segovia. In the first war in Cuba he fought against Spain, reaching the grade of colonel. Afterward he wrote a book entitled "From Yara to Zanjón," in which he refers in his style to the principal military and political incidents of that large and bloody campaign. We have read it and found in it some curious things.

Collazo is now nothing less than a general, and he has prepared an expedition in the United States, from which the separatists expect great things. The worst is, it has not yet started, because the North American authorities will not consent, and there is danger of its being broken up.

Salvador Cisneros Bethancourt, Marquis of Santa Lucia, born in Puerto Principe, of one of the principal families of Camagüey. He was president of the first republic, succeeding Céspedes in the office. He did nothing worthy of particular mention, and at the close of the war remained in Puerto Principe, occupying himself with the cultivation of his lands. He is a man very advanced in years, without other prestige than his name and the office which he held. It appears that he is also president of the government constituted recently, but we are not certain, since it is scarcely eight months since they began the war, and we have seen various presidential candidates, and we do not know which is the true one.

As to the biography of Manuel Céspedes, we are forced to declare that he has none. He is the son of Carlos Manuel Céspedes, who gave the signal for the first rising in Yara, on the 10th of October, 1868, and who was killed near Asserradero, Cuba, February 27, 1874. He has recently published a book presenting the papers of his father, and now intends to go to Cuba with an expedition.

OUR FISHES AND FISHERIES.

THERE is a great deal of interesting information in the report of the Commissioner of Fish and Fisheries, Mr. Marshall McDonald, which has recently been published. In the single year covered by it there were furnished for distribution by the various stations 12,068,000 eggs, 165,235,800 fry, and 1,486,117 adults and yearlings. There were also other supplies furnished, but lost in transit, among them being 3,857,000 shad fry and 1,100,000 pike perch fry.

The largest distribution, taking eggs and fry together, was of whitefish, 54,692,000, with shad next at 45,330,000, and then pike perch at 45,330,000, cod at 22,187,500, quinnat salmon at 8,820,300, lobster at 8,818,000, and lake herring at 6,505,000. Various kinds of trout, salmon and bass were prominent, and notable among the adults and yearlings were catfish, carp, tench and 12,588 goldfish.

At the Wood's Holl laboratory studies of marine life were prosecuted. Dr. Kellogg, for example, studied the early habits of the common scallop or pecten, and also wrote a paper on the morphology of lamellibranchiate mollusks; Prof. Herrick continued his researches into the life history of the lobster; Prof. Wilson observed the development of sponges, and Dr. Patten dwelt on the sense organs in the horseshoe crab. Indeed, many reports and papers were published. The steamers Plover, Canvasback, Blue Wing, Curlew, Cygnet, Shearwater and Petrel were kept in good condition for the Fish Commission's work.

Investigations of the fur seal fisheries, of the other fisheries in waters contiguous to Canada and the United States, and of oyster beds in Chesapeake Bay, at Galveston and at Sea Isle City were made. Those of Prof. Ryder at the latter point were aided by an annual appropriation of $5,000 a year by New Jersey for three years, and he hopes to develop, in return, an industry worth millions through his experiments in oyster culture. One of Prof. Riley's conclusions starts almost epigrammatically: "Oysters are like potatoes; they will stay just where you plant them. The only one of their stages that is locomotive is the fry or swimming stage." Dr. Bashford Dean suggests that the degree of density of the water is one of the most important factors influencing the spawning and fattening of the oyster.

The studies of Prof. Libbey, in the Grampus, disclosed the return of the tilefish, which seemed to have been exterminated in 1882 between Cape May and Nantucket, and the influence of temperature, both on the disappearance and the reappearance, was traced out.

In New York and New Jersey pound nets have come more into use, partly with the result of fewer seines, while many more gill nets are found, due to the development of the shad and sturgeon fisheries of the Hudson and the Delaware. There was noted a general increase of the fishing industries in these two States. It is stated that the catch of the following products, among others, has increased: Alewives, bluefish, butterfish, catfish, eels, flounders, mullet, sea bass, shad, squeteague, sturgeon, tomcod, lobsters, quahogs and oysters. The following are taken in smaller quantities than formerly: Cod, mackerel, menhaden, scup, sheepshead, Spanish mackerel, striped bass, soft clams, crabs and terrapin.

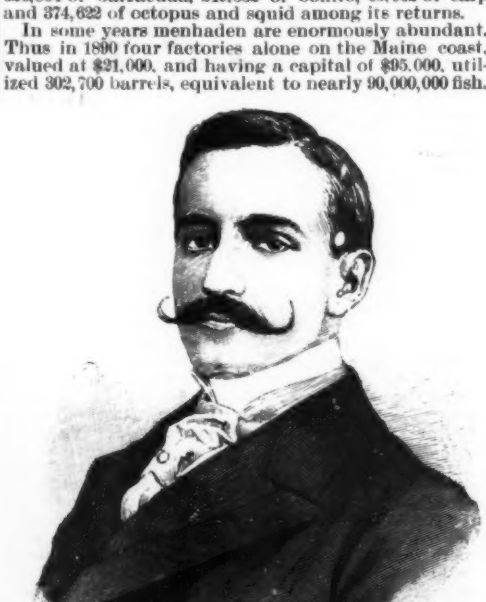
The mackerel, lobster and clam fisheries of New England occupied much attention. The number of vessels in the mackerel fleet in 1892 was about 200, and the catch was reported to be about 40,000 barrels of fresh and 47,000 of salt mackerel, making a total value of about $1,000,000. George's Bank continued to be the chief resort off the New England coast for the fleets from Gloucester, Boston, Provincetown and other ports.

On the Pacific coast the fisheries form a most important industry. In 1892 they employed in the three States of California, Oregon and Washington 14,045 persons, and property and capital valued at $6,392,064, with products of 123,116,858 pounds, valued at $4,826,964. California shows 150,175 pounds of anchovies, 326,804 of barracuda, 249,332 of bonito, 65,662 of carp and 374,622 of octopus and squid among its returns.

In some years menhaden are enormously abundant. Thus in 1890 four factories alone on the Maine coast, valued at $21,000, and having a capital of $95,000, utilized 302,700 barrels, equivalent to nearly 90,000,000 fish.

ENRIQUE COLLAZO, GENERAL OF THE FIRST REVOLUTIONARY ARMY.

D. SALVADOR CISNEROS BETHANCOURT, MARQUIS OF SANTA LUCIA, FORMER PRESIDENT OF THE CUBAN REPUBLIC.



MANUEL CESPEDES, PROMOTER OF THE CUBAN REVOLUTION.

CHIEFS OF THE FIRST CUBAN REVOLUTION.

From these were made 1,059,000 gallons of oil, with a market value of $264,760, and 10,930 tons of wet scrap or "chum," valued at $131,160. The fish were supplied by nine steamers, carrying about 200 men, and there were also 306 shore employes, to whom $38,640 was paid in wages. The following year the catch fell off over 50 per cent.

Red snappers were very abundant on Campeche Bank, off Galveston, in 1893. Three smacks were employed, and steam vessels made trips to bring off their catch. This continued from early in the year to May 6, and included 321,056 pounds of red snappers, with other fish bringing the total of 367,808 pounds. The smacks were manned by from eight to twelve fishermen each. The snappers generally weighed from three to twenty pounds, large ones being numerous. The fish were taken by hand lines, and as many as 20,000 pounds were caught in one day by the three smacks.

STRANGE BEDFELLOWS.

OUR illustration of a lioness cub and bull terrier pup is from a photograph by Lieutenant E. H. Stafford, R.E., whose property the lioness cub was. She came from Somaliland, and was seven months old at the time the photograph was taken. She was as tame as a cat and was kept loose as a pet from the age of six weeks until she was thirteen months old, but subsequently she was confined in a cage at night. She was perfectly good tempered with those whom she knew, and never hurt anyone. She had a great friendship for her master's little bull terrier pup, whom she would allow to eat out of her own dish. She did not care, however, for the close companionship of the pup's parents.—The Graphic.

[L. C. MIALL, IN NATURE.]

THE TRANSFORMATIONS OF INSECTS.

So much special work has been done during the last thirty years upon the transformations of insects that written specially upon insect transformations before he collected his matured thoughts into a book. His "Origin and Metamorphoses of Insects" is now very widely known. It is by far the most readable exposition which we possess, and will long hold its place as an interesting account in simple language of that part of the subject which involves no special knowledge of insect anatomy. Some day it should be supplemented by an account of the mechanism of pupation, showing in detail how various larvæ are converted into winged insects. It is on this side that insect transformations have been most successfully attacked during the last thirty years.

It is natural that after an interval of many years we should find what seem to be deficiencies in the work of those who have gone before us. The most notable deficiency which I find in Lubbock's book is that he does not remark the great distinction between insect metamorphoses and those of most other animals.* They occur, as I think, in a different part of the life history and arise out of conditions which are different or even diametrically opposite. There are other points, too, which seem to me to be passed over too briefly by Lubbock and all previous writers. In particular, certain aphorisms of Fritz Müller seem to me to deserve a fuller explanation than they have yet received.

Such inevitable gaps in the expositions of our predecessors render it possible to supplement even works which have attained the rank of classics. Each generation for a long time to come will be able to add its quota of facts and reflections without exhausting this immense and difficult subject of inquiry. It is satisfactory to note that Lubbock's account has been very little disturbed as to matters of fact by later investigations, so that his readers, though they have plenty still to learn, have very little to unlearn.

Let me first attempt to justify my contention that the transformations of insects are fundamentally unlike the transformations of polyps, echinoderms, mollusks and crustaceans. In the marine groups the minute animal, just escaped from the egg, passes rapidly through its changes, often before the yolk is absorbed. It may complete them before it begins to feed, always long before it has attained its full size. The insect, on the contrary, undergoes its most striking change of form after it has attained its full size. Moreover, the planula of the polyp, the bipinnaria or pluteus of the echinoderm, the Nauplius or Zoæa of the crustacean, are unknown except as transitory forms. But the less specialized insect larvæ make a very close approach to certain lower, wingless insects in their adult state. The insect larva, before it gives place to the pupa, has not only attained its full size and acquired a form answerable to that of some perfectly adult insects, but it already contains in many cases completely developed reproductive products; indeed, a very few insects are known to be capable of reproduction as larvæ. It seems to me preposterous to say, as Harvey did in the 17th century, that the insect larva is a kind of walking egg, or with Quatrefages that it is an embryo which leads an independent life. It would be far more truthfully described as an animal which has attained the normal structure of adult Arthropods, though it has still to undergo a peculiar adult transformation. Where the insect larva falls short of that adult structure, it is because abundance of food, or some other external circumstance, has induced degeneration, but we shall best understand insect larvæ in general by comparing them to sexually mature myriopods, protracheates, scorpions and Thysanura.

Adult transformation is rare among free-living animals, though parasites furnish many examples. The Ctenophora, instead of settling down early, maintain a pelagic life, and become specially modified thereto in a late stage of development. The secondary sexual characters assumed by some birds and mammals at the time of sexual maturity, such as the train of the peacock or the antlers of the stag, are analogous facts. But the closest parallel to the transformation of insects is to be found in the Amphibia. Frogs and toads, having already as tadpoles attained the full development of the more primitive Amphibia, change to lung-breathing, tailless, land-traversing animals. The motive is the same as that which led to the acquisition of wings by insects. It is by virtue of their adult transformation that both the amphibian and the insect are enabled to wander from the place of their birth to seek out mates belonging to other families and to lay their eggs in new sites.

In those Amphibia which undergo transformation, the stage added to the life history of the more primitive forms is not the tadpole, but the frog or toad. In those insects which undergo transformation, complete or incomplete, the winged state is the new addition. If a pupa appears in the life history it results indirectly from the acquisition of wings by the adult. Hence it seems to me that in Amphibia and insects the peculiar change, which renders possible all the rest, belongs to the adult condition, i. e., these animals undergo an adult metamorphosis.

Transformation in the inhabitants of the shallow seas is closely related to the crowded state and severe competition of the area. The connection is twofold. Unusual risks imply numerous eggs, numerous eggs must be small, and small eggs with little or no yolk hatch early, producing very immature animals unlike their parents. Again the risks of the shore favor heavy armored species, and it is well known that a great proportion of the invertebrate fauna of the sea shore is defended in this way. But heavy armor diminishes activity, and in particular often renders swimming impossible. The dispersal of the species is therefore left to the young fry, which are often specially organized for locomotion at the surface of the sea. Marine animals which are not armored, such as the Cephalopoda, may undergo no transformation at all.

DOMESTICATION MAKES STRANGE BEDFELLOWS.

I lately resolved to spend some time in reviewing the most important facts which have been ascertained respecting the structural changes which take place before or during pupation. I had not gone far before I found it necessary to clear up my own thoughts as to the nature of insect metamorphosis, and the way in which it had come about. Some preliminary considerations upon these points, inferred from facts which have long been known, I now propose to discuss, leaving the more special facts to some future occasion.

Three naturalists, Fritz Müller (1864),* Friedrich Brauer (1869),† and Sir John Lubbock (1874),‡ have in our own time written upon the origin of insect transformations. It was, as they themselves tell us, Darwin's "Origin of Species" which incited each of them to look at the old facts in the light of a new theory. Fritz Müller, being at the moment specially occupied, not with insects, but with crustaceans, threw out casually, as it were, a number of general results of the greatest interest and value, which he did not attempt to support nearly so fully as his own knowledge of insects would have enabled him to do. Brauer, a little later, travelled over the subject in a somewhat more leisurely way. The most important principles had already been indicated by Müller, but he was able to contribute many facts of special interest and to point out a definite and rather widely distributed larval stage, of which much has since been said in discussions on the phylogeny of insects. I need not remind English naturalists that, even before 1874, Sir John Lubbock had won fame by his researches into the life history and habits of insects. He had also

Certain general propositions concerning larval transformation are disturbed if the adult transformation of insects and Amphibia is included. Indeed, I was first led to notice the distinction between adult and larval transformation by observing that insects and Amphibia do not conform to the general rule, that while the inhabitants of the shallow seas go through transformations in early life, fluviatile and terrestrial animals do not.

Every animal and every plant has these two functions (among others) to fulfill. It must feed and grow; it must also separate from its fellows and find out an unoccupied site. The two functions may be discharged together. Birds, for instance, feed all round the year and change their abode whenever they suffer from overcrowding or scarcity of food. In other cases, either function may, for special reasons, be limited to a particular time of life. The crustacean cannot migrate effectively when adult, because of the heavy armor which it carries. The insect cannot migrate effectively when young, because of the difficulty of travel by land. It is easy for a minute animal to travel by sea. The high specific gravity of the water renders the body buoyant, and currents, even where special locomotive organs are absent, will do the work of transport. Power to rise and sink in the water is convenient, but even this is not strictly indispensable. On land the conditions are very different. The weight of the body has to be supported in a comparatively rare medium, and much greater exertion is called for. Running, leaping and flying are difficult exercises, much better performed by the adult than by the

* "Facts for Darwin" (Für Darwin).

† Verh. Zool. bot. Ges. Wien (1869). Of less importance is Part 2 (1878).

‡ "Origin and Metamorphoses of Insects." (Appeared originally in Nature, 1873.)

* I am not aware that any one else has made more than a passing allusion to this distinction, but I may easily have overlooked some important reference in the vast literature on insect transformations. Macleay has remarked that in insects the change of form takes place during their last two or three stages, whereas "the metamorphosis of all other Annulosa only occurs during the first or second moult after leaving the egg." (Illustr. Zool. South Africa, p. 53.) I do not find this distinction recognized as part of ordinary biological knowledge in our best treatises on development, such as Balfour, or Korschelt and Heider.

larva, if these should happen to differ materially. It is often of advantage that there should be division of labor between the several stages of the life history, and the functions of migration and growth may be allotted to special times of life instead of being carried on throughout. Migration is naturally associated with lightness and activity; feeding and rapid growth are favored by a sedentary habit. If such division of labor should take place, as it commonly does in crustaceans and insects, the crustacean will find it convenient to perform its migration early, when it has little armor to carry, and when its surface is large in proportion to its weight. The Zoœa will do little more by its own exertions than maintain the right attitude and the right distance from the surface of the sea, leaving the currents to effect the actual transport from place to place. Migration over, it will settle to the bottom, acquire heavy armor as a defense from its many enemies and begin to feed in earnest, becoming in the end a slow and heavy inhabitant of the sea bottom. With the insect the procedure will be reversed. Being unable to travel far while small and weak, it will feed first, and having attained its full size, will then, if at all, acquire special means of locomotion. Wings are more efficient as a means of transport than any other organs of locomotion of which a terrestrial animal can avail itself; but flight is so difficult an exercise that wings, if acquired at all, will be acquired late.

Marine animals commonly produce far more eggs than insects.* The risks of the shallow seas are so great that a small proportion only of the young animals comes to maturity. Hence the enormous fertility of common marine animals, except such as are able to nourish or defend their young. Where a vast multitude of eggs hatch out together, dispersal in search of food becomes an immediate necessity.

The more sluggish and sedentary the adult, the greater the activity we may expect to find in the larvæ. It is they which have to travel and to find out suitable quarters. But they often make up by their numbers for any deficiency in enterprise or intelligence. Vast numbers of Zoœas are swept into midocean or into tidal rivers or are devoured. It is only a chance remnant that survives.

Just as the sluggishness of the adult crustacean or echinoderm may promote activity in the young, so the activity of the adult insect may discourage activity in the young. The power of flight possessed by most adult insects favors a sedentary life in the larva, which is spared all effort in connection with the dispersal of the species, and can give its undivided attention to feeding. Accordingly the larva often degenerates more or less, especially when its food is abundant and obtained without labor or risk. The sagacity and industry of the bee in storing its cells with honey may be said to have cost the larva its legs. So, too, the active and highly gifted blowfly, ichneumon, and gall fly secure abundant food for the new generations, which emerge as footless grubs. In the Coleoptera we find that the larvæ, which feed on dead vegetable matter beneath the surface of the ground, are heavy bodied and short legged, sometimes so overloaded by the weight of the abdomen that they rest lying on one side. The larvæ of weevils, which are vegetable feeders and often buried in the plant which they devour, are commonly without legs altogether. Even the head of the larva may be reduced almost to nothing by the labors of the adult insect. The blowfly finds out a practically inexhaustible supply of carrion in which to lay its eggs, and the larval head is so reduced that it consists mainly of a pair of large hooks, with muscles to work them, and a chitinous frame to form a fulcrum for the muscles.

The degeneration of the larva can only proceed far when the adult undertakes the dispersal of the species. That is why, it seems to me, the larvæ of marine animals, though often very unlike their parents, are not really to be called degenerate. They cannot be supposed to have arisen from ordinary forms, typical of the class, by mere disuse and reduction of the organs of active life. On the contrary, they are often immature forms specialized for locomotion.

Even when the adult undertakes the dispersal of the species, the larva does not necessarily become degenerate. The winged locust is the chief agent in dispersal, but the larvæ are active, seek their own food, and exhibit no marks of degeneration. It is only when their choice and responsibility are taken away, when they are encouraged to feed almost without intermission, or to bury themselves out of sight, that they degenerate.

Parental care and all labors undertaken by the parent for the sake of the offspring tend to promote helplessness in the young. The helplessness of the higher vertebrates at birth, as well as their prolonged fœtal development, are due to the fact that their parents are able to find them food and protection. Here there is no degeneration in the young; though helpless, they are of the same zoological grade as their parents. The locomotive organs and the senses of a baby or a nestling bird are as complex as those of the adult, and are merely feeble for want of skill and exercise. In the larval insect there may be real degeneration, fewer limbs, fewer joints in the limbs, deficiency of sense organs, relative preponderance of the organs of nutrition. If the transformation of insects had never been traced, the structure of the two stages would have inevitably led zoologists to place the caterpillar in a lower class or order than the butterfly.

There has been much speculation as to the form of primitive insects. Fritz Müller supposes that the wingless Orthoptera come near to the original stock, while others have derived all insects from the wingless and non-metamorphic Thysanura. By taking what is common to the least modified Orthoptera and the Thysanura, and rejecting all features peculiar to either, we shall certainly get a highly generalized insect, such as might possibly be a common ancestor for the whole group. Brauer pointed out that such primitive insects still survive in Campodea and Japyx, which have mouth parts (as Lubbock considers) "intermediate between the mandibulate and haustellate types," one pair of many jointed antennæ, three pairs of long legs, and an abdomen whose first seven segments bear pairs of rudimentary appendages, while the tenth and last segment bears in Campodea a pair of many jointed appendages, in Japyx a forceps. Campodea and Japyx have no eyes, but this is not considered typical; simple eyes are usual in insects of the same grade. They undergo no metamorphosis.

* No statistics have been collected to my knowledge on an extensive scale. Very many insects lay their eggs singly. In particular cases (social insects, Meloidæ, etc.), where special reasons obtain, they may be laid in great numbers, but my general impression is that the eggs of Echinoderms or marine Crustaceans would be far more numerous as a rule.

Brauer finds forms closely resembling Campodea among the larvæ of Orthoptera, Perlidæ, Odonata, Ephemeridæ, Coleoptera and Neuroptera. In Strepsiptera and Coccidæ he considers that they are present in a more modified form. No Campodeiform larvæ occur among Lepidoptera, Hymenoptera, or Diptera.

Brauer looks upon the caterpillar of Lepidoptera, sawflies and Panorpa as a degenerate Campodea, while he considers the apodous maggot of many Coleoptera, some Neuroptera, bees and Muscidæ as a still more degenerate larva, derived from, and not historically antecedent to, the Campodea. Grassi and others have brought forward facts to show that the maggot-like bee larva has previously passed through a kind of Campodea stage.

Lubbock regards the caterpillar too as essentially a Campodea. But this extension seems to me to take all definiteness out of the Campodea form. If every larva with biting mouth parts and six legs is to be called a Campodea, we still want a name for the larva which has long legs, long antennæ and at least one pair of abdominal appendages.

Brauer's Campodea seems to invite comparison with Scolopendrella and Peripatus; just as the more generalized Campodea of Lubbock invites comparison with the hexapod larva of Diplopoda and Atax. I do not venture to pursue these comparisons, which involve difficulties not apparent at first sight, and will only remark that the former comparison seems to throw most light upon the phylogeny. The leg-bearing segments of the Diplopoda are apparently not the same as those of insects, and the embryology of insects points to a polypod, rather than to a hexapod, as the common ancestor of the Tracheates.

If it seems rash, with our present knowledge, to trace the phylogeny of Peripatus, the Myriopods and the insects, what shall we say of Lubbock's far bolder attempt to derive his Campodeiform larva from a Rotifer-like ancestor? It is suggested, though not positively asserted, that certain apodous dipterous larvæ exemplify this earlier stage. I must declare myself altogether skeptical as to a Lindia stage antecedent to the Campodea. The only apodous insect larvæ known to me are born of highly specialized insects, and have apparently become degenerate in consequence of the completeness of the provision made for them by the intelligence or special instincts of the parent. They are, as Brauer humorously says, like the sluggards in Hans Sachs' Lubberland, who required roast pigeons to fly into their mouths. I see in them no mark of a primitive insect.

Brauer in 1869 was ready to derive the maggot from the caterpillar, and the caterpillar from the Campodea (p. 310). He points out, very truly, that the reduction of the larval head of the Diptera may be gradually traced from forms in which it is perfectly developed. It is a pity that he did not bear his own explanation in mind when at a later date he attempted to arrange the Diptera Nemocera by characters largely drawn from the degree of development of the larval head. The unsatisfactory nature of the result has been pointed out by Baron Osten Sacken (Berl. Ent. Zeits., Bd. xxxvii, p. 417, 1892).

That Brauer's arrangement of the Nemocera does not, in the opinion of experts, associate allied forms, shows that he has been unfortunate in his use of larval characters. Could that result have been anticipated? Is there any general objection to the employment of larval characters in the definition of large groups of insects? I think that there is. In his paper of 1869 Brauer, following Fritz Müller, remarks that the development of various insects has been either abbreviated or falsified. He thinks that the Hemiptera have lost a transformation which they once possessed. He thinks that Dipterous larvæ and others have been acted upon by conditions of life which have not affected the imago. Yet he has employed characters which he knew to be highly adaptive and also finely gradated, for the definition of his tribes and families. Brauer is both a systematist and a philosopher, but his system forgets his philosophy.

(To be continued.)

THE STRUCTURE AND FUNCTION OF THE HORSE'S FOOT.*

By Veterinary Captain F. SMITH, F.R.C.V.S., F.I.C.

THE structure and function of the horse's foot is a subject which is not only of theoretical interest, but of supreme practical importance. When I tell you that half the unsoundness and at least half the lameness among horses in this kingdom are due to trouble either in or near the foot, you will, I am sure, agree with me that it is impossible to overestimate the importance of the subject which I have to bring before you this evening.

The reason why the foot should be such a frequent seat of unsoundness is not difficult to understand when we remember the unnatural conditions under which horses both in town and country have to work, and, further, the risk they incur from shoeing.

Shoeing is a necessary evil, but the harm resulting from the application of a shoe to the foot is not in itself great; it is the abuse of shoeing which constitutes the danger. The serious and senseless mutilations which are practiced on the foot rob shoeing of much of its value, and constitute it a standing reproach to our civilization.

I regret that the time at my disposal will not admit of the question of shoeing being touched on; but during this discourse, as opportunity occurs, I will allude to some of the great evils which are practiced in this indispensable art, evils which I may at once say might in a few months be swept away throughout the length and breadth of the land, if the horse-owning community possessed even an elementary knowledge of the manner in which the horse's foot is built up, and the use of its various parts.

* A paper read before the Royal Institution of Great Britain, May 3, 1895.

It is probable that the majority of laymen regard the foot as a solid block of horn placed at the end of the limb, and on which the horse stands. I shall hope to show you that the foot is a highly specialized structure, endowed with tissues possessing acute sensation, mechanisms by which concussion is warded off, a blood supply unequaled in any other part of the body, the whole being inclosed within a covering of horn known as the hoof.

The foot is therefore divided into two parts, a core consisting of bones, blood vessels, tendons and other tissues, which in shape resembles a miniature hoof, and enveloping this a covering of horn possessing neither blood vessels nor nerves; the first is called the sensitive, the other the insensitive foot, and the two fit together much as a finger fits into a glove.*

Various names have been given to the different parts of the foot: For instance, the wall is the portion visible when the foot is on the ground; the position of the sole is obvious; while a wedge-shaped piece of horn placed in the central and posterior part of the foot is vulgarly known as the "frog"—we shall speak of it as the foot pad; finally, a portion of the wall inflected at the heels forms a part known as the bars.

It is impossible to completely grasp the function and structure of the foot unless we possess some information as to the nature of horn.

If horn be examined under the microscope, it is found to consist of cells which resemble the scales found on the skin; in fact, hoof is modified skin, the cells forming which have, by a process of compression and chemical change, become converted from scales of skin to scales of horn.

The essential microscopical feature is the presence of canals, around and between which the cells are arranged, uniting and knitting the parts together in such a way as to produce the tough, yielding material known as horn. The tubes run through the entire length of the structure. They are not completely hollow, as the name might imply, but are lightly packed with very soft cells.

Horn which is dry, as in any of the feet on this table, is as brittle as glass and fractures like a piece of glue. Horn which is moist cannot be broken; it can be twisted and torn, but only with difficulty. Under pressure the moist horn yields, the dry horn breaks.

The moisture in the foot is something very remarkable. In the foot pad it amounts to 42 per cent., while in the wall, which is the driest, it falls to 24 per cent. The use of this moisture is to keep the foot pliable and yielding; where, therefore, the greatest yielding is required there the moisture is the largest, and where resistance is most needed there the moisture is the least. I shall constantly have to refer to the moisture in horn, for, as you will see later, it is the essential factor in the foot around which all the others work.

It is through the cells and tubes in the horn that a constant passage of water occurs, by which means the foot maintains, in spite of the evaporation which is taking place from it, the amount of moisture it requires.

We spoke of the sensitive being buried within the insensitive foot; it is from this sensitive foot that the horn is secreted, the process being a slow and gradual one. If we examine a horn-secreting surface, it will be found covered with delicate projections known as papillæ, about one-quarter to one-half inch in length; these papillæ fit into holes in the horn, and the tubular formation of horn is due to the fact that it is pierced at its origin for the reception of papillæ.

The wall of the horse's foot is divided, for convenience of description, into the toe, quarters and heels. The thickness is greatest at the toe, and decreases gradually toward the heels, where it is thinnest; but the wall at the heels, instead of being continued so as to complete the circle of the foot, suddenly turns in and travels in a forward direction between the sole and foot pad. This portion is called the bar, and the practical lesson which has to be learned is that the bar is part of the wall, is intended to bear weight and should not be cut away in shoeing, as is so commonly practiced. In a foot of a wild horse shot in Thibet—of which a plaster cast is placed on this table—the most extraordinary development of the bars is shown.

It is obvious that by the inflection of the wall the heels of the foot are considerably strengthened; and this is especially necessary, as the circle of the wall is only an imperfect one.

The amount of moisture in the wall varies, depending upon its position relative to the horn-secreting surface. The horn-secreting surface of the wall lies immediately under the upper edge of the hoof; the nearer the horn is taken to this upper edge, the more moisture it contains, the further from the edge, the less the moisture. It is obvious, therefore, that as the wall grows longer it becomes drier, and moderate dryness of horn is only another name for toughness, so that the portion of wall in contact with the ground is much harder than the portion above the ground.

The growth of the wall under normal conditions is the same at any part of its surface; if it grows an inch at the toe, it grows an inch at the quarters and heels. You will observe that the wall at the heels is, roughly, only half the height of the wall at the toe, and, bearing in mind what has been previously said about horn becoming drier as it increases in length, you will have no difficulty in understanding that the horn at the toe is older and tougher than the horn at the heel, which, from being much younger and shorter, contains more moisture and is, therefore, elastic and yielding. If, for example, we assume the length of the wall at the toe to be four inches, and that at the heel to be two, it is obvious that the wall at the toe is double the age of that at the heel; and if we continue this investigation further by drawing lines around the wall parallel with the upper edge of the hoof, it will readily be seen that the portion in contact with the ground is of varying age, being oldest at the toe and gradually decreasing in age to the heel, in other words, being hardest at the toe and softest at the heel.

There is an object in all this which we must now inquire into. When a horse's foot comes to the ground in either the trot, canter or gallop, viz., in any pace which causes concussion, the heel is the first to make contact with the ground; by this means, as we shall

* A working model of the foot twelve times its natural size was kindly built for this lecture by Captain Gillespie, army service corps, to whom I am very greatly indebted.

hope to show, the shock of impact is considerably reduced, for the soft tissues of the posterior part of the foot yield slightly under the strain instead of offering rigid opposition, and this yielding, which we shall have to deal with more fully later on, is permitted to occur through the young moist horn which exists at this part.

From the heel the weight is transmitted along the foot from rear to front, and finally the heel becomes raised, the toe alone bearing on the ground. This is the position in which the greatest wear and tear of the foot occurs, for the toe is now engaged in giving the propulsion to the body, the friction is, therefore, considerable, and to meet this the horn at this part is comparatively dry and very tough.

We can see, therefore that the variations in the amount of moisture in the wall are intended to meet the wear and tear of the foot.

The use of the wall is to support the weight of the body; the horse's weight is literally slung inside its foot. This slinging apparatus is infinitely stronger than if the weight were imposed, as we might imagine, on the sole of the foot, and, in addition, it is distributed over a larger surface than it otherwise would be.

When we remember that the mean weight of a horse is 10 cwt., and there are many which weigh 15 cwt. or more, there is no difficulty in observing that the foot is really an extremely small base on which to impose this enormous weight. The area of the human foot appears to be greater than that afforded by the horse's foot, but I shall now have to show you that the slinging apparatus previously spoken of increases in a remarkable manner the internal surface of the horse's foot without adding to its circumference.

Found on the inside of the wall are 500 or 600 plates or leaves of horn which run in the direction of the fibers of the foot—they may be seen in this model. In length they nearly correspond to the wall, while they are so thin as to be perfectly transparent. Regarded by themselves, their function is not very evident; but if we examine the exterior of the sensitive foot, it will be observed that it is covered with a very large number of delicate sensitive leaves, also of extreme thinness, and so full of blood vessels as to give a bright red color to the part.

These sensitive leaves or laminæ correspond in number and position to their insensitive counterpart, and the two sets are found to be fitted into each other in such a way as to form the most perfect dovetail.

This dovetailing of the laminæ produces immense strength; by no ordinary process is it possible to destroy the union of these two surfaces, even after death; special methods have to be adopted in the study of anatomy if we wish to separate the horny from the sensitive laminæ.

But the dovetailing is further increased in strength by a remarkable arrangement. If we make a horizontal section of the two sets of laminæ in position and examine them microscopically,* we find that each lamina, both horny and sensitive, possesses secondary laminæ or lamellæ; of these there are about 150 to each primary lamina, so that we may say the union between the sensitive and insensitive walls is brought about by the dovetailing of 1,000 primary and 150,000 secondary laminæ.

Here is a model of a single lamina 450 times larger than normal. The structure rather reminds one of a fern leaf or feather, the stem being the primary lamina and the lateral projections the secondary leaves.

So much for the slinging apparatus. If time permitted I could tell you much more of interest about it; and the undoubted evidence we possess that by it, and it alone, is the enormous weight of a horse's body solely supported.

We have one more point to discuss in connection with the laminæ, and that is the increase in the surface which they afford to the foot. The simplest method of explaining my meaning is to take the commonplace example of a book consisting say of 500 pages, which when bound in the ordinary manner is easily compressed into a body having a small surface, yet if each of the 500 pages be removed and placed side by side, the area they cover would be considerable. Much the same arrangement exists in the foot. By the folding up of horny and sensitive material a very large surface is disposed within a very small circumference, and careful measurements of the primary and secondary laminæ have led to the conclusion that the surface thus contained within each foot of the horse is not less than eight to ten square feet.

The next part of the foot to receive attention is the sole. This, as may be seen from the model and diagrams, is concave in shape toward the ground, which is evidence, if any were required, that it is not intended to support the horse's weight; that margin of it, however, in contact with the wall is doubtless capable of sustaining pressure.

The function of the sole is to save the sensitive parts situated above it from injury, and that it is eminently qualified for this purpose is evident to any one who has witnessed the intense lameness which arises from a stone getting wedged in the foot.

The sole grows from the sensitive sole, which may be seen in the diagram to be scarlet in color and covered with numerous projections, or papillæ, which fit into minute holes on the upper surface of the horny sole.

A peculiarity in the horn of the sole is the fact that it only grows a certain thickness before it breaks off. The object of this is, that as the sole over its general surface is not in contact with the ground, it is exposed to little or no friction like that of the wall, which in a state of nature is maintained of proper length by the friction to which it is exposed. The sole is therefore shed on attaining a certain thickness, but no shedding occurs until a new sole of suitable thickness has been produced to take its place.

One of the common evils of shoeing is cutting away the sole of the foot. If we bear in mind the use of the sole, I am sure the ruin produced by this barbarous practice will be very evident to you. The sole cannot be too thick, and I have shown you that nature provides for its exfoliation. Under the weight of the horse's body the sole slightly yields: but this we will discuss presently.

The foot pad, or, as it is commonly known, the frog, is peculiar both from its shape and the nature of its horn. The horn forming this body is very soft, and resembles rubber; it can be cut, but offers considerable resistance to friction, and when exposed to friction it wears away with a ragged surface in much the same way as rubber. Its pliability is due to the considerable amount of moisture it contains, which you may remember I stated was as high as 42 per cent., or about double that found in the wall.

This foot pad has a sensitive counterpart, a body composed of fibrous material containing fat, and so like fat in color that it has been termed the fatty frog. This sensitive foot pad fills up the entire space between the heels of the foot, and forms a dense cushion exactly resembling in shape the foot pad, and it is from the surface of this cushion that the horny foot pad grows.

There is no part of the horse's foot which has been exposed to more mutilation in shoeing than the foot pad; probably there is no part of the equine less understood, or one where more ignorance has been shown.

The impression among laymen is that the foot pad is a dangerous excrescence, which regularly at every monthly shoeing must be cut away to prevent the horse from becoming lame. This practice, I regret to say, is countenanced by people of intelligence, who in the matter of horse shoeing place themselves entirely in the hands of their servants.

The use of the pad is to save the foot and limb from concussion: its position in that part where I previously told you the largest amount of concussion is inflicted is evidence of this; further, the rubberlike nature of its horn is suggestive of a mechanism for the prevention of jar and shock. The shape of the pad, and the fact that in the unshod or carefully shod foot it is in contact with the ground over a large surface, is evidence that it must assist in providing a firm foothold and prevent slipping. Finally, from its position and use it keeps the heels apart and maintains the proper width of the foot.

All these facts can be absolutely demonstrated. Take, for instance, the last function accorded the pad, viz., maintaining the proper width of the heels of the foot. A simple experiment will demonstrate this to perfection. If we take a foot with a large well developed pad, and so shoe the horse that it does not come in contact with the ground, the heels of the foot become narrower every day, and in three months' time the part is beyond recognition, the heels have curled in, the pad has folded in on itself so that it is not one half its original width, and the fibrous cushion previously mentioned as lying above the foot pad wastes away as it is thrown out of use.

We may now reverse the experiment, and shoe the horse in such a manner that what is left of the foot pad is made to rest on the ground: in a month, or even less, the most marked changes have occurred, the pad commences to unfold itself like a bud, the cushion becomes larger, the foot wider, and in three months the transformation may be complete. Such is an experiment which may be performed on any horse with absolutely identical results, and proves to demonstration that the pad is intended by nature to rest on the ground.

We must now take a cursory glance at the internal foot, as our time will not admit of a complete examination.

The bones found in the foot are three in number: two wholly belong to the foot, one belongs partly to the foot and partly to the portion of the limb above the hoof known as the coronet. Dealing only with the foot bones, one is found to resemble a miniature hoof in shape, is very porous in its structure, and has growing from each extremity a plate of cartilage which extends superiorly above the hoof and posteriorly as far back as the heels. The bone is porous to admit of the innumerable blood vessels for which the sensitive foot is remarkable, while the introduction of the plates of cartilage is to allow of lateral movement in the posterior part of the foot, such as would not be possible if bone existed in its place.

The second bone of the foot is one of the smallest, but practically one of the most interesting in the body. Its position can be seen in this model; and it is unfortunately the seat of the most incurable lameness to which the horse is liable. Beneath this small bone is a tendon which flexes the foot and keeps the bone in position.

Surrounding all these are the sensitive structures to which previous reference has been made. But before passing on to the final subject for our consideration, I must draw your attention to the remarkable vascularity of the foot; in few parts of the body do we find so many blood vessels. These diagrams can give you but a faint notion of the number of vessels in the foot, and even they deal only with the veins; to have introduced the arteries would have complicated the drawing too much. Practically the whole of the sensitive foot is scarlet in color, from the amount of blood it contains, and the sole use of this blood is to manufacture the horny covering.

We alluded just now to two plates of cartilage found in the foot; they occupy the position shown in the diagram, and their use is connected with the important lateral movement or expansion which the foot undergoes when weight is placed on it. If it were not for these elastic plates, expansion of the foot would be rendered very difficult. The plates also assist the circulation of the blood in the foot, by exercising, during their elastic movements, pressure on the veins, and thus pumping the blood out of the part.

Perhaps the greatest interest in the foot is centered in the mechanisms which prevent concussion. these are as follows: lateral expansion of the foot, descent of the vascular within the horny foot, flattening of the sole, and sinking of the heels.

The expansion of the foot has been known for many years, but has always found more opponents than supporters; it was not until the introduction of foot apparatus which was capable of making delicate measurements that it was possible to convince the incredulous. Lungwitz, in Germany, has made some valuable observations on the expansion of the foot. Independently and unknown to each other we were both reinvestigating the phenomenon with improved apparatus, and obtained results which were practically identical. I show you on the screen the apparatus employed by Lungwitz, which consists chiefly of a shoe to which can be fitted an arm carrying a screw. To this arm one pole of the battery of an electric bell is attached; the wall of the foot is covered with tinfoil carefully secured in its place, and to it is attached the other pole of the battery; the contact screw is so adjusted that if the foot widens when the weight is placed on it, the tinfoil touches the screw and so closes the circuit, of which the bell gives the indication. With this and other apparatus Lungwitz investigated the movements of the foot not only at rest, but during work.

I have been unable to investigate the movements of the foot during work, but on the table may be seen a piece of apparatus constructed on the same lines as that employed by Lungwitz, and with it I shall be able to show you, even on the dead foot, that there is marked lateral expansion. There is another piece of apparatus which I have employed, not only to indicate lateral movement in the foot, but to register the amount. The apparatus is constructed on the lines of a well known form of steam gage; a pin is connected with a series of wheels which multiply its movement, and convey this for the purpose of registration to a hand working on a dial; a very small amount of movement in the pin gives rise to a considerable excursion of the hand on the dial; by dividing the dial into a certain number of parts and carefully estimating their value by means of a vernier, an apparatus capable of registering the $\frac{1}{128}$ of an inch is readily obtained. I have this instrument on the table; it is placed against the wall of the foot at any desired spot, and, by lifting up the opposite leg, and so throwing extra weight on its fellow, the foot expands. A large number of observations carried out on these lines demonstrated that during rest simply imposing extra weight on one fore foot by lifting up its fellow caused it to expand $\frac{1}{32}$ of an inch.

It may be asked what is the value of this trifling increase? My answer is that this "give" makes all the difference between a rigid and a yielding mass, the slight yielding saves the foot from jar and concussion. It is obvious that the amount of "give" depends upon the force with which the foot comes to the ground, viz., on the pace, but under no circumstance is it likely to be more than $\frac{1}{8}$ of an inch.

The only part of the foot which expands is that portion of the wall situated toward the heels.

On this large model I have shown you in section the arrangement of the bones within the foot, and I pointed out the existence of a small but exceedingly important bone, the seat of an incurable lameness. The question arises as to the use of the navicular bone. My reply to a rather complex question must be brief—it is to increase the area of the pedal joint. It is obvious that an increase in the area of the joint could have been obtained by making the pedal bone itself larger, instead of introducing a third bone into the joint for the purpose. You will, however, observe from this model that the navicular bone has a movement quite independent of that of the pedis. It gives slightly when I press upon it and then returns to its place. Bearing in mind what I told you early in this lecture, that the heel of the foot comes to the ground first in all fast paces, you will be able to see that this small and troublesome bone really forms a yielding articulation, on to which the first force of impact is imparted, and in this way concussion is prevented. When this bone becomes diseased the animal, as we might imagine, goes on its toes and loses all freedom in its gait.

The next mechanism to be described is the descent of the vascular within the horny foot, a process which can be perfectly seen in this model. The whole of the vascular foot under the influence of the body weight sinks or becomes depressed within the hoof, to rise again to its position when the weight is taken off the limb; to revert to our original simile, the finger slides up and down within the glove. The amount of this movement is about one-sixteenth of an inch. The effect of it is that the foot offers an elastic and not a rigid resistance to the concussion of impact, and in this way neutralizes the jar which would otherwise be felt, in the same way that it is easier to catch a cricket ball by a retreating movement of the hand than by rigid opposition.

At the moment of the descent of the internal foot, the horny sole, which you will remember is concave toward the ground surface, becomes slightly flattened, as the result of which no bruising of the delicate structures convering the sensitive foot is incurred.

If we place a foot rule in such a position that one arm is resting on the ground, while the other is lying parallel to the wall of the foot at the toe, and in this position lift up the opposite foot so as to throw double weight on the one under investigation, it will be found that at the moment the extra weight comes on the limb the upper or coronary edge of the hoof slightly recedes from the foot rule; when the extra weight is taken off the foot, the edge advances into its original place. This phenomenon is associated with a sinking of the upper edge of the hoof at the heels and an increase in the width of the foot.

The change in shape just described follows as the result of a temporary rearrangement in position of the parts within.

We have previously drawn attention to the very vascular nature of the horse's foot; time will not admit of stopping to inquire into the causes of this vascular condition, but what chiefly strikes the physiologist is that a part lying furthest from the heart should be able to have such a complex circulation carried on with comparative ease. Does the foot in any way assist in its own circulation? The experiment which I am about to show you proves this very conclusively, and demonstrates that a pumping mechanism exists, by which the blood is forced out of the foot every time the weight comes on it.

Into the veins of this foot I have placed two glass tubes, and both are filled with water; by projecting these tubes on the screen you will be better able to observe that at the moment I press on the foot joint—and thereby, as you will remember, depress the internal foot and at the same time cause the whole part to slightly expand—the fluid rises considerably in the manometer tubes; when I remove the pressure the fluid falls. Now in the living foot when the weight comes on the limb, the blood is pumped with considerable force up the veins of the leg, and at every move-

* A number of microscopical preparations were placed on the library table illustrating the structure of the foot. The majority were kindly prepared for this lecture by Professor Mettam, B.Sc. Dick Veterinary College, Edinburgh.

men this is repeated. That the living foot behaves like our dead one, is proved by the fact that if a vein be divided in the living animal, a jet, as if from a syringe, comes from it every time the foot comes to the ground.

The pumping action in the foot is due to the various movements occurring in this organ, and without their aid it is probable that the circulation in the foot would be carried on with extreme difficulty.

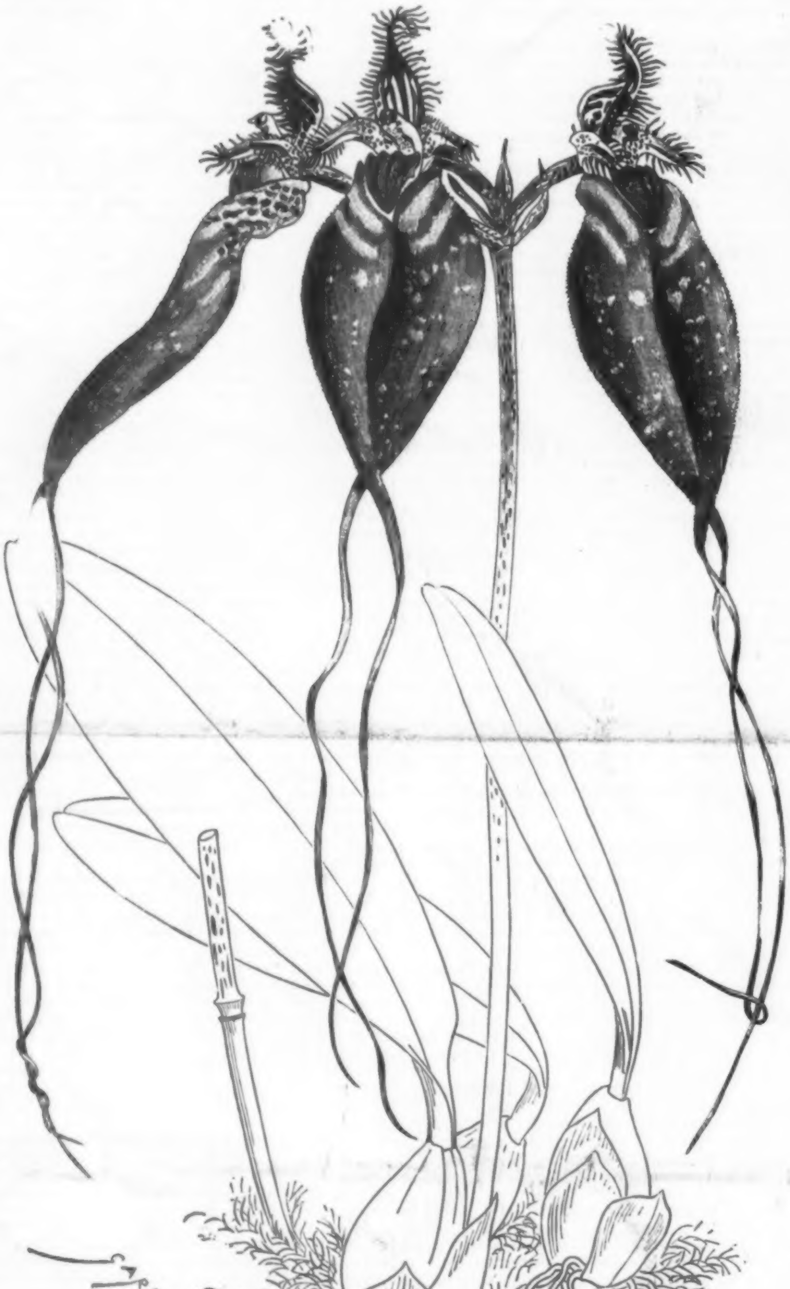
Finally, let us briefly pass in review the changes occurring in the foot from the time it makes contact with the ground until it leaves it.

The weight is received on the posterior part of the foot and foot pad, by which means the plantar cushion resting above the foot pad is altered in shape; the foot pad and plantar cushion being compressed and widened, each exerts pressure on the part of the foot with which it is in contact, so that both the wall of the hoof and the elastic cartilages are pressed outward, and expansion of the foot occurs. Concurrently with this the weight has been received on the posterior part of the pedal joint with its yielding articulation formed by the navicular bone. By the time the whole foot is flat on the ground, the entire sensitive foot has become depressed within the horny envelope, the heels of the hoof have sunk, and the coronary edge traveled backward. The body now passes over the foot, the limb revolves as it were around one point, viz., the foot joint, and finally the heels leave the ground, their width becomes decreased, while the final propulsion to the body is given by the toe, which is the last part of the foot to leave the ground.

The hour allotted to this discourse has expired. I have had to take you very hurriedly, and I fear very imperfectly, over a considerable amount of ground, such, indeed, as might have occupied our attention for several lectures, but I trust I have awakened an interest in a very important subject, and that something may have fallen from me which will be of use to you and to that animal to which we are all so much attached.

CIRRHOPETALUM ROTHSCHILDIANUM, n. sp.

At the meeting of the orchid committee of the Royal Horticultural Society on October 15, the Hon. Walter Rothschild exhibited what was unanimously agreed to be the handsomest of the plume-bearing section of Cirrhopetalum, and under the above name it was awarded a first class certificate—an honor only once before accorded to a member of this singular genus. The plant was received from an explorer somewhere in the hills beyond Darjeeling a few years ago, but owing to its long and slow journey it, together with a few others, chiefly new botanical orchids, arrived in so withered a condition that only this season, after careful nursing, has it succeeded in flowering. As the cultivated pseudo-bulbs are scarcely one-third the size of the imported ones, it is but reasonable to infer that the flowers, beautiful though they are, will still improve as the plant gains strength. The pseudo-bulbs vary in form from ovate to pear-shaped, each bearing a single fleshy light green leaf, more or less distant on the rhizomes. Scape erect, 8 inches in height, bearing at the top a one-sided umbel of flowers, each over 6 inches in length, and exceeding one inch across the broadest part of the lower sepals. The prevailing color of the flowers is bright crimson purple, some blotches of clear yellow appearing on the sepals. The cucullate upper sepal is yellow with purple lines, and with marginal fringe and a very sensitive plume of a purple color at the apex. The petals are narrower, but similarly colored and decorated. The lower sepals show little other color than rich crimson purple, the same hue pervading their slender tail-like appendages which sometimes intertwine and at others are free. The triangular, grooved, hinged labellum is purple, and the whole flower so remarkably attractive as to command attention even from those who profess to care for nothing but the showiest orchids. Its nearest affinity seems to be C. Collettii, Hemsl.—The Gardeners' Chronicle.



CIRRHOPETALUM ROTHSCHILDIANUM—FLOWERS BRIGHT PURPLE, WITH YELLOW MARKINGS.

THE

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